

**CLIMATE CHANGE AND TRANSPORTATION:
CHALLENGES AND OPPORTUNITIES**

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**CLIMATE CHANGE AND TRANSPORTATION:
CHALLENGES AND OPPORTUNITIES**

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To Jake, a loyal friend and member of the family
You will never be forgotten
We love and miss you

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LIST OF SYMBOLS AND ABBREVIATIONS

AFV	Alternatively fueled vehicle
APTA	American Public Transportation Association
AQMA	Air quality maintenance area
ARB	California Air Resources Board
ARC	Atlanta Regional Commission
ARTA	Auckland Regional Transport Authority
BART	Bay Area Rapid Transit
B100	100% biodiesel from soy beans
B20	20% biodiesel and 80% diesel
BCC	Brisbane City Council
BMPO	Boston Region Metropolitan Planning Organization
BRT	Bus rapid transit
BTU	British thermal unit
CAFE	Corporate Average Fuel Economy
CAMPO	Capital Area Metropolitan Planning Organization
CEQA	<i>California Environmental Quality Act</i>
CH ₄	Methane
CMAF	Chicago Metropolitan Agency for Planning
CMAQ	Congestion Mitigation and Air Quality Improvement Program
CO ₂	Carbon dioxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EIR	Environmental impact report

EISA	<i>Energy Independence and Security Act of 2007</i>
EPA	Environmental Protection Agency
EU-15	Pre-expansion members of the European Union
EWGCC	East-West Gateway Coordinating Council
DEIS	Draft environmental impact statement
FEMA	Federal Emergency Management Agency
GBNRTC	Greater Buffalo-Niagara Regional Transportation Council
GHG	Greenhouse gas
GIS	Geographic information system
GMPB	Growth Management Policy Board
GWRC	Greater Wellington Regional Council
HFC	Hydrofluorocarbon
H-GAC	Houston-Galveston Area Council
HOT	High occupancy toll
HOV	High occupancy vehicle
ICLEI	International Council for Local Environmental Initiatives
IPCC	Intergovernmental Panel on Climate Change
ITS	Intelligent transportation system
kg	Kilogram
lb	Pound
LCCP	London Climate Change Partnership
LEV	Low emissions vehicle
LOS	Level of service
LTZ	Limited traffic zones
MARC	Mid-America Regional Council

MBTA	Massachusetts Bay Transportation Authority
MPG	Miles per gallon
MPO	Metropolitan planning organization
MTC	San Francisco Metropolitan Transportation Commission
Mt	Megatonne
MUNI	San Francisco Municipal Rarilway
N ₂ O	Nitrous oxide
NCHRP	National Cooperative Highway Research Program
NJTPA	New Jersey Transportation Planning Authority
NYBPM	<i>New York Best Practice Model</i>
NYMTC	New York Metropolitan Transportation Council
PAYD	Pay-as-you-drive insurance
PFC	Perfluorocarbon
PMT	<i>Program for Mass Transportation</i>
PPP	Public private parternship
PSRC	Puget Sound Regional Council
RTD	Regional Transportation District of the Denver area
RTP	Regional transportation plan
RUC	Road User Charging
SACOG	Sacramento Area Council of Governments
SAFETEA-LU	<i>Safe, Accountable, Flexible, Efficient Transportation Equity Act</i>
SEStran	South East of Scotland Transport Partnership
SF ₆	Sulfur hexafluoride
SIP	State implementation plan
SJCOG	San Joaquin Council of Governments

SJVAPCD	San Joaquin Valley Air Pollution Control District
SOV	Single-occupant vehicle
SR	State route
TAZ	Traffic analysis zone
TCM	Transportation control measure
TCRP	Transportation Cooperative Research Program
TDM	Travel demand management
TfL	Transport for London
TIP	Transportation improvement program
TMG	Tokyo Metropolitan Government
TOT	Truck-only toll
TRB	Transportation Research Board
USCCSP	United States Climate Change Science Program
VHT	Vehicle-hours traveled
VKT	Vehicle-kilometers traveled
VMT	Vehicle-miles traveled
VOC	Volatile organic compound
ZEV	Zero emission vehicle

SUMMARY

Transportation in the United States is responsible for a disproportionate amount of global greenhouse gas emissions, which contribute to climate change. To address the issue, strategies that seek to mitigate transportation-related greenhouse gas emissions and adapt transportation systems to the threats of a more inhospitable climate should be developed through the transportation planning process. The transportation plans and related documentation of 60 metropolitan planning organizations, 13 domestic cities, and 27 large international cities were reviewed to ascertain if climate change considerations are being incorporated into transportation planning. The review of transportation plans revealed that climate change considerations are often not incorporated into the planning process, especially in regard to adapting transportation systems to the effects of climate change due to the inherent uncertainties in climate data and risk analysis. On the other hand, greenhouse gas mitigation is more frequently included in the planning process, when compared to climate change adaptation, because the required data collection techniques and analysis tools are better developed and already in place within many planning organizations. This research has shown that there is much room for improvement in terms of including climate change into transportation planning through a variety of recommendations presented in the body of this thesis. Many of the identified mitigation and adaptation recommendations could be worked into existing transportation planning requirements, processes, and strategies at the metropolitan and local level. However, due to the influence by federal and state governments on the planning process, completely addressing climate change through transportation systems will require these

high levels of government to redefine transportation regulations and planning requirements in addition to partnering with metropolitan planning organizations and local governments to develop more reliable climate data and increase its availability.

CHAPTER 1

INTRODUCTION

Most climate scientists agree that climate change¹ has been occurring in scientifically measured ways ever since Man first became industrialized and that it will continually become more pronounced if not addressed on a global scale. Though the specific threats will vary by region, the effects of climate change generally include a warmer climate, changes in precipitation patterns, higher severity storms, increasing risk of flooding and larger storm surge, expedited melting of vital snow and permafrost, and more frequent erosion. These hazards will have serious implications on a wide variety of natural and human systems, but this thesis specifically focuses on the implications for transportation. The relationship between surface transportation and climate change is twofold: global transportation is responsible for a significant portion of climate change through the emissions of greenhouse gases², and the effects of a changing climate could have serious consequences on the safety and preservation of surface transportation systems.

Greenhouse gases essentially trap more of the sun's heat energy in the earth's atmosphere, causing an increase in temperature over time that consequently affects weather processes around the world. Transportation is one of the largest emitters of

¹ From the Intergovernmental Panel on Climate Change (IPCC): "a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer" (1)

² Methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbon (HFC), perfluorocarbon (PFC), sulfur hexafluoride (SF₆), and carbon dioxide (CO₂) (2)

greenhouse gases in the world. In the U.S., transportation accounts for approximately 28% of all greenhouse gas emissions, which, due to the disproportional energy consumption of the United States versus the rest of the world, translates to roughly 6%³ of global CO₂ emissions (2, 3). In addition, transportation-related CO₂ emissions have begun rising dramatically throughout the U.S. in recent years because of rapidly growing vehicle miles traveled (VMT) and stagnant average fuel economy, as shown in Figure 1.1. From 1990 to 2005, transportation-related CO₂ emissions have risen 29%, representing the second largest increase of any economic sector (excluding U.S. territories) and outpacing the percentage growth of total U.S. CO₂ emissions (2).

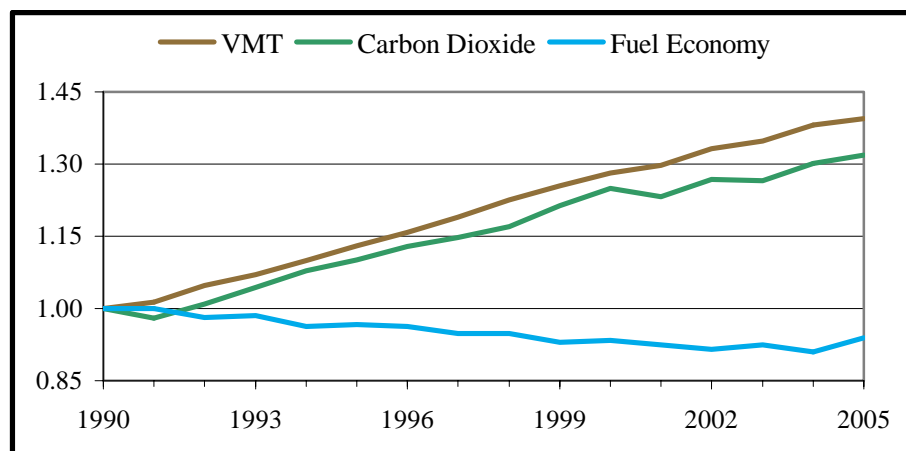


Figure 1.1 VMT, CO₂⁴, and fuel economy trends from 1990-2005 (4, 5, 6)
Index (1990 = 1.00)

³ CO₂ accounts for 95% of all greenhouse gases emitted from transportation sources in the U.S., and the country is responsible for an estimated 22% of global CO₂ emissions. (28% * 95%) * 22% ~ 6%

⁴ EPA estimated CO₂ emissions are from all modes of transportation, including aviation. The post-September 11th aviation fallout may partially explain the dip and slowed growth from 2001 to 2005.

The tremendous growth in both the rate and total amount of greenhouse gas emissions will likely increase the magnitude of climate change effects and the exposure of the transportation system to corresponding threats. The nature of these climate threats will vary from region to region, generally depending upon an area's geographical layout, typical climate conditions, and latitude, among other factors. In response, there is now discussion (7, 8) among the transportation community about the need to develop adaptive strategies to increase the resilience of the transportation system to likely climate change threats.

1.1 Study Need

Based upon the relationship between climate change and transportation systems, there is a real need for the transportation planning process to consider surface transportation's influence on and response to a changing climate. The need to address climate change through the planning process is particularly evident in the U.S. due to a lack of national leadership and guidance on the issue coupled with the disproportional energy consumption compared to the rest of the world. The present lack of published information regarding transportation planning and climate change in the U.S. makes such a topic quite suitable for investigatory research. In addition, the urgency to respond to climate change threats will only grow in time, which will require immediate planning action to meet the challenges and address the opportunities that can make a difference over the near and long term.

1.2 Study Objective

Much of transportation planning occurs at the metropolitan and local level. Consequently, the objective of this thesis is to investigate current metropolitan planning

organization (MPO) and municipal efforts to incorporate climate change considerations into the planning process and provide recommendations on linking transportation planning and climate change in response to the results of the review.

1.3 Study Overview

This thesis reviewed available online transportation planning documents of major MPOs and domestic and international cities, and then used a conceptual transportation planning framework as an organizing tool to report relevant climate change findings. The selection process for MPOs was straightforward. The MPOs of the largest 75 cities in the United States were initially considered, but because some MPOs contain multiple large cities, 60 unique MPOs were ultimately reviewed for this research. For domestic and international cities, an Internet search using various search engines was carried out to find locations where climate change is discussed within the context of transportation planning. In all, 13 domestic and 27 international cities were summarized. Google's translation software⁵ was used when international information was not in English. The results of the initial documentation review are presented in Appendix A.

1.3.1 Literature Review

The literature review in this thesis focuses on general climate change adaptation and mitigation strategies due to a lack of published information regarding the incorporation of climate change considerations into the transportation planning process. The adaptation section is discussed in terms of a risk-management concept, while the mitigation portion is primarily concerned with vehicle and network efficiency, fuels, VMT reduction, and government policies and programs.

⁵ http://translate.google.com/translate_t

1.3.2 Conceptual Framework

The conceptual framework chapter begins with an explanation of the conceptual planning framework that will provide a generalized background of the transportation planning process. Afterwards, the application portion of this chapter reveals the important findings of the review of MPO and municipal online planning documentation organized by each step in the planning process.

1.3.3 Discussion and Recommendations

The discussion and recommendations chapter summarizes the key findings of the conceptual framework application. This chapter, including the recommendations on how to incorporate climate change into the transportation planning process, is broken down by individual steps of the conceptual planning framework. Recommendations for each planning step are also presented in a summary table (Table 4.1) at the end of the chapter.

CHAPTER 2

LITERATURE REVIEW

The link between climate change and the transportation sector is based on the fact that transportation sources emit a surplus of greenhouse gas into the atmosphere and these gases have the ability to alter the world's climate. Even though this link is well understood, there is little research that investigates how MPOs and local governments are addressing such a serious issue, if at all. This research failed to find a published report that explores in-depth the metropolitan and local efforts across the country to incorporate climate change into transportation planning. The following literature review will focus on the general strategies that are available to combat climate change from the transportation perspective, and then determine which strategies may be of use specifically at the metropolitan and local level. The literature review is divided into two types of strategies, adaptation and mitigation, to represent the distinct areas of climate change research.

2.1 Adaptation

Present trends and forecasting climate models suggest that temperatures will continue to rise during this century (1). In fact, “anthropogenic warming and sea level rise would continue for centuries due to the time scales associated with climate processes and feedbacks, even if GHG concentrations were to be stabilized” (1). Under these scenarios, the intensity of weather events (heightened rainfall rates, flash flooding, and more severe tropical storms) and augmented temperature variability pose threats to infrastructure ill equipped to handle such extremes (8). Coastal and inland water

locations may potentially see the most devastating effects on infrastructure in the short-term due to frequent flooding and more powerful storm surges, while increased temperatures and stronger wind loads might have escalating importance in the long-term (9). The “Federal Emergency Management Agency (FEMA) estimated that about a quarter of homes and other structures within 500 feet of the U.S. coastline and Great Lakes shorelines will be overtaken by erosion [from sea level rise] during the next 60 years” (10). In response, adapting transportation infrastructure and operations to likely damaging effects of climate change is becoming an increasingly important planning concern.

Studies that analyzed potential climate impacts in New York and New Mexico came to similar conclusions (11, 12). In coastal areas of New York, storm surge and flooding were seen as the greatest climate threat. The report concluded that adaptation strategies should focus on land use, such as relocating and preventing development in flood areas, and redesigning infrastructure not only to withstand amplified heat and wind, but most importantly flooding. New Mexico’s study found that most of its impacts were from warmer temperatures, including faster pavement and rail line deformation, increased likelihood of wildfires causing infrastructure damage, and various maintenance issues such as additional mowing from a longer growing season and heat-related health concerns for maintenance employees. Moreover, though initial reports suggested that Canadian transportation stood to benefit from climate change, “many of the [previous] conclusions were based on limited information and/or analysis” (13). It may be accurate to assume warmer winters would mean less operational and maintenance expenditures due to less snowfall, and could even provide improved safety from slick winter roadways,

but infrastructure costs in various regions, like pavement rutting in southern Canada and roadway deterioration from more freeze-thaw cycles and loss of permafrost base in northern Canada (13), would probably outweigh the benefits.

It is evident that some governments and organizations are beginning to acknowledge potential climate change effects on their infrastructure and operations. According to the Pew Center, six states either have completed or are working on adaptation plans, while another five states have climate action plans that recommend the creation of adaptation plans (14). Potential deficiencies and areas of concern are now being highlighted and exposed, so the question now shifts from how climate change will impact infrastructure and operations to how these impacts should be addressed and accounted for in transportation planning and decision making. The U.S. Climate Change Science Program's (USCCSP) recent report, *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I*, advocates that a risk management methodology rather than current deterministic methods should provide better information on climate-related risks (7). The study presents a conceptual risk-management framework in detail. This thesis is concerned with interactions between transportation and climate change at the metropolitan and local level, and because the USCCSP risk management framework was developed specifically with state and local governments in mind and is presented in a general manner to ensure regional transferability (7), it was chosen as the backbone of the adaptation portion of this literature review. With climate changes expected to vary from region to region (1), utilizing a generalized framework for adaptation makes sense. Figure 2.1 shows a visualization of the conceptual framework.

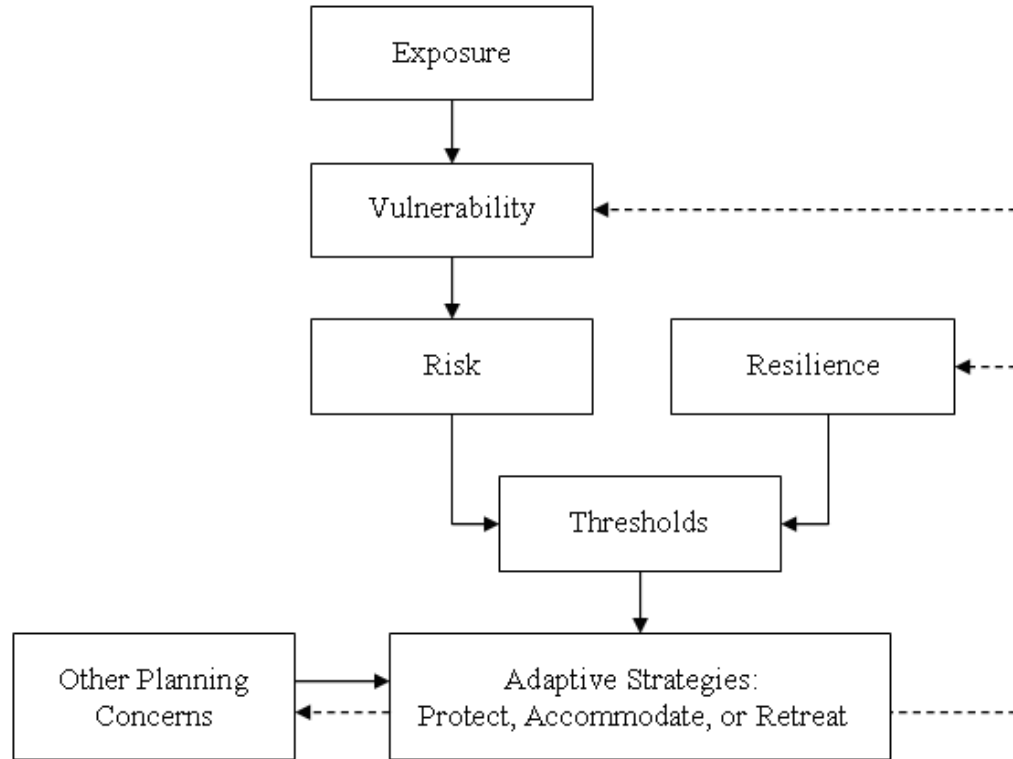


Figure 2.1: Conceptual risk management framework adapted from ideas presented in *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure: Gulf Coast Study, Phase I*

The dashed lines in Figure 2.1 represent the circular nature of the framework, as the adaptive strategies have direct influence on various components during the next iteration, which will be discussed in the subsequent section. The following is a summary of specific components adapted from the USCCSP report with additional insight from other literature.

2.1.1 Risk Management Framework

The conceptual factors of the risk management framework are defined in the study as follows:

- *Exposure*: “The combination of stress associated with climate-related change (sea level rise, changes in temperature, frequency of severe storms) and the probability, or *likelihood*, that this stress will affect transportation infrastructure.”
- *Vulnerability*: “The structural strength and integrity of key facilities or systems and the resulting potential for damage and disruption in transportation services from climate change stressors.”
- *Resilience*: “The capacity of a system to absorb disturbances and retain essential processes.” (7)

Estimating the level of projected exposure is the first step in the framework, and it is the most ambiguous of all conceptual factors. Predicting how the climate will change and where its effects will be felt is difficult for many reasons. Climate science itself is based upon statistical tests of weather variation, with results of studies presented in terms of probability of occurrence that can range anywhere from *virtually certain*, or >99%, to *exceptionally unlikely*, or <1% (1). Uncertainties in climate analysis results are only amplified when attempting to specify effects on anything smaller than a global scale, such as metropolitan or local infrastructure within the scope of this report. It is said that the precision of reduced-scale climate analyses is improving, but variability even within regions (such as local elevation changes) generates further difficulty in assessing true climate risks (8). The USCCSP report briefly mentions an analysis of different climate scenarios, but does not discuss how the analysis was performed (7). Perhaps a qualitative assessment of likely effects given a region’s geographic and weather characteristics is the best option until regional analysis tools become more accurate and widely available. In spite of methodological shortcomings, the recent Transportation Research Board (TRB)

climate change report suggests “transportation professionals will have to confront and adapt to climate change without knowing the full magnitude of expected changes” (8)

Once the types and probabilities of weather events are established with reasonable certainty, determining the vulnerability of infrastructure and operations can begin. It is important to precede vulnerability assessment with an exposure analysis to ensure the correct transportation deficiencies are accounted for. Specifically for transportation, vulnerability is a function of location and integrity of infrastructure and the ability of transportation operations to withstand disturbance (7). Infrastructure management procedures are vital in quantifying facility vulnerability. Ideally the infrastructure management process is iterative and provides useful information concerning a facility’s condition as a function of its age, structural deficiencies, extent of use throughout service life, etc. Evaluating a facility’s relationship with its environment is also necessary. For example, a bridge in a low-lying area may be structurally sound and operationally efficient, but if the height of its bridge deck is too low then it is vulnerable to flooding. The bridge’s vulnerability is derived from the potential for it to cease functioning during severe storms. It is because of the bridge’s vulnerability during continued heavy rainfall that it is viewed as a risk from the probable effects of climate change. For this framework, the common definition of risk (the product of exposure likelihood and damage or disruption costs characterized by facility vulnerability) is used (7).

Resilience, a concept that defines more than just physical strength, is the final conceptual factor of the framework and helps define the true costs associated with potential risk. The term is classified by three dimensions within the USCCSP report, including:

1. “Mode/structure:

- Repair/replacement cost; and
- Replacement timeframe.

2. Socioeconomic:

- Public support;
- Interorganization cooperation;
- Economic resources; and
- Social resources.

3. System level:

- Redundancy among components;
- Essential service resumption;
- System network connectivity;
- Institutional capacity; and
- Relevance of existing plans for response to events (e.g., floods).” (7)

From these categories one can see that transportation resilience is generally a function of repair/replacement issues, social and economic resources, and network connectivity and redundancy. For example, the resilience of the nation’s rail network was demonstrated by its redundancy after Hurricane Katrina crippled the New Orleans region and forced the CSX to reroute much of its freight throughout the region (8). CSX has since rebuilt its damaged rail lines and bridges, but is considering less vulnerable locations farther from the coast.

The threshold, or “point where a stimulus leads to a significant response,” is the next component of the framework and is naturally a function of the identification of risks

associated with and the resilience of transportation infrastructure, among other planning inputs (planning horizons, budget/organizational constraints, stakeholders, etc.) (7).

Infrastructure thresholds essentially serve as inputs to the transportation planning process and are generally: “(1) economic write-off, when replacement costs less than repair and (2) a standard-derived threshold, when the condition of the infrastructure component falls below a certain standard” (7). Defined thresholds, when considered within the umbrella of planning goals and objectives and organizational characteristics, will ultimately lead to adaptation strategies, otherwise referred to as the adaptive response.

The USCCSP report presents three distinct adaptive responses in the framework: protect, accommodate, or retreat (7). The option to protect facilities would most likely be reserved for infrastructure that is of critical importance or expensive to replace or repair, or transportation operations that are vital to the well being of an area. Fortunately, protection against risk is already considered when designing facilities (8). For example, infrastructure design standards in certain regions of the country already account for seismic activity to create structurally sound facilities. More generally, these standards assume worst-case scenario weather extremes based on historical weather data, otherwise known as 100-year storms, to protect against common or rare conditions. The design standards also help ensure that structural integrity of bridges remains during large wind gusts or efficient traffic operations continue throughout heavy rainfall thanks to adequate drainage systems. However, there is concern that the typical 100-year storm could become more frequent under climate change scenarios and thus create serious problems of risk and safety (8). One solution is to strengthen current design standards and improve facility resilience based upon climate risks.

The critical need for stronger standards that can handle more powerful and frequent weather extremes is already recommended in several reports (1, 8, 11, 15), although the process to change standards is time-consuming and requires accord among many transportation professionals and organizations (9). Aside from the lengthy revision process, improving design standards creates another concern. As the TRB report puts it, “attempting to hedge by simply designing to a more robust standard—say a higher wind speed tolerance or a 500-year storm—will produce much more costly designs, likely to be unacceptable given limited budgets” (8). The same report recommends combating the issue with selective risk management techniques that weigh costs of failure along with costs of superior design criteria (8), which fits within the components of the risk management framework.

Accommodation, the next adaptive response, can be thought of as accepting the risk and living with it as best as possible. A good example of an accommodation strategy is an evacuation plan for a coastal area. In this case planners and officials have chosen to live with the occurrence of severe storms because protecting the entire region from every effect of such weather events is not feasible. Retreating, the third adaptive response and considered a last resort, would involve terminating the use of a facility. If it is not possible to protect or accommodate a facility, abandoning it may be the only option provided there is sufficient risk. Once abandoned, replacement infrastructure may be built in a location that is less vulnerable. Meyer recommends the practice of “location engineering,” citing the successful use of flood insurance maps to help determine drainage requirements, and suggests the concept could be used more formally as a tool to adapt to climate risks (9).

The risk management conceptual framework represents an iterative process (represented by dashed lines in Figure 2.1) because the adaptive strategies will ultimately redefine a region's vulnerability (e.g. developing more durable facilities) as well as aspects of its resilience both at the facility level (e.g. longer replacement timeframes) and the systems level (e.g. new operational plans or increased network redundancy). Continually changing exposure to climate extremes guarantees that an area's definition of risk will vary as regional climate science becomes more accurate and conditions likely worsen over the time long term. The relationship between adaptive strategies and planning/organizational inputs is also a two-way road. Implemented adaptive strategies can help shape components of the dynamic transportation planning process, such as goals and objectives, time horizons, and budget constraints, while these same components directly influence the creation of adaptive strategies. TRB also recommends that the adaptation process be regularly evaluated for effectiveness (8).

The literature has made it clear that adapting transportation infrastructure and operations to climate change will be difficult, especially due to uncertainty, but not impossible. The authors of the USCCSP report point out that addressing such uncertainty is not out of the question for transportation planners. "Transportation decision makers are well accustomed to planning and designing systems under conditions of uncertainty on a range of factors – such as future travel demand, vehicle emissions, revenue forecasts, and seismic risks" (7).

2.2 Mitigation

Climate change may be unavoidable, but the magnitude of change is certainly alterable. The most significant and well-known worldwide effort to reduce future

greenhouse gas emissions is known as the Kyoto Protocol, which became active for many countries in 2005. The Protocol requires an emissions reduction of 5% below 1990 levels by the 2008-2012-period for developed countries that ratified the agreement (16). The 5%⁶ goal is an aggregate target comprised of reduction goals that vary by developed country. For example, the European Union goal is -8% for all of its EU-15⁷ members while the Icelandic goal stands at +10% (this is still considered a reduction over a projected emissions increase) (16). Developing countries are exempt from concrete reduction targets, though many of these nations still emit large total amounts of CO₂ (e.g. China). For this reason, the U.S. has yet to ratify the Kyoto Protocol and is subsequently not subject to any prescribed emissions cutbacks from the international community. Support, however, for greenhouse gas reductions within the U.S. is still growing despite the lack of ratification.

Many regional and local initiatives in the spirit of the Kyoto Protocol are now being developed and expanded within the U.S. (and North America) even without federal support. Some well-known example regional initiatives include (17):

- Regional Greenhouse Gas Initiative:
 - Goal: 10% below capped 2009 levels by 2019
 - Members: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, and Vermont
- Midwestern Regional Greenhouse Gas Reduction Accord:
 - Goal: As much as 80% below current emissions (agreement drafted in 2007)

⁶ All Kyoto Protocol-based percentage reductions are relative to 1990 emissions levels

⁷ Pre-expansion European Union members

- Members: Illinois, Iowa, Kansas, Manitoba, Michigan, Minnesota, and Wisconsin
- Western Climate Initiative:
 - Goal: 15% below 2005 levels by 2020
 - Members: Arizona, California, Montana, New Mexico, Oregon, Quebec, Utah, and Washington

Collectively, the geography of all initiative members (excluding Canadian provinces) covers an estimated 37% of total U.S. greenhouse gas emissions (18). The primary method of reduction for the three initiatives is a cap and trade system, which essentially caps the amount of greenhouse gases that can be emitted into the atmosphere. Permits, or allowances, that reflect the unique emissions by private companies or other organizations, such as utilities and governments, are distributed and traded among these organizations. An organization that pollutes less may sell their excess emissions allowances to another organization that may need to pollute more. This creates an incentive to emit less greenhouse gas and increases the economic viability of alternative energy methods. A cap and trade system was a major component of the recently debated congressional bill, *America's Climate Security Act of 2007*, which failed to pass through congress as of June 2008.

Cap and trade systems are an important part of the mitigation equation, but are often mostly concerned with mitigating power generation and industry emissions rather than transportation emissions. The *Western Climate Initiative Work Plan*, however, does discuss the possibility of including liquid fuels, passenger and light duty vehicles, and transportation fleets as components of the cap and trade system (19). But if the U.S. is

going to come close to reaching the necessary emissions reduction to stabilize climate change (estimated at 60-80% below 1990 levels by 2050 (20)), much more will have to be done, especially within the transportation sector.

Fortunately, more could be done. Cap and trade programs, which would fall under government policies and programs, are only one element of commonly discussed mitigation strategies of Figure 2.2. There are four general strategies available to mitigate greenhouse gases: improve transportation efficiency, lower carbon intensity of fuels, reduce VMT, and enact various governmental policies and programs (20, 21, 22).

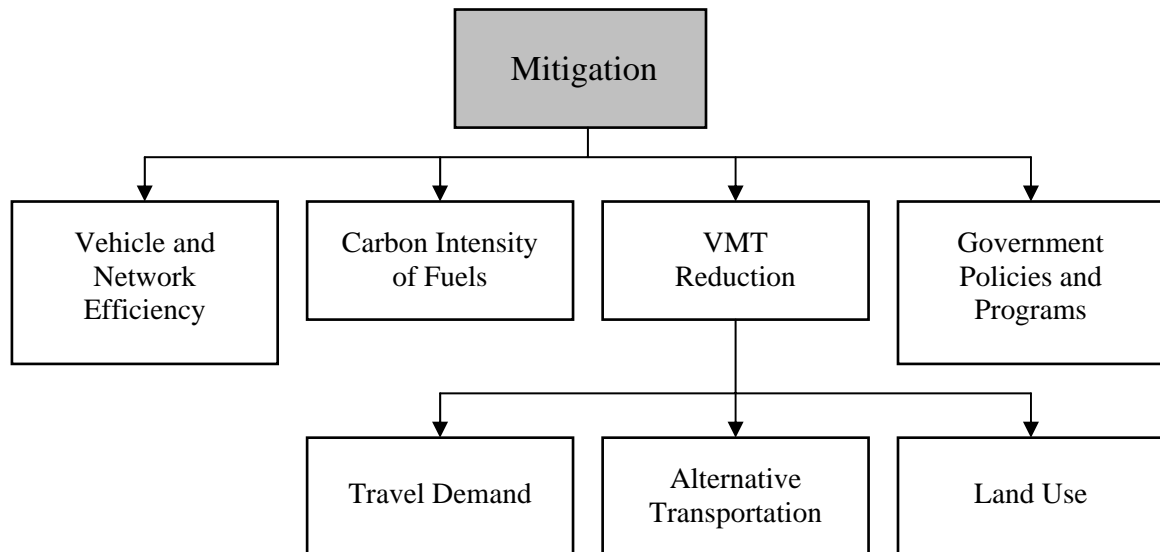


Figure 2.2: General strategies for greenhouse gas mitigation

Some of these strategies are currently being employed by a number of the 852 cities that are part of The U.S. Mayors Climate Protection Agreement. The voluntary Agreement was created by Greg Nickels, Mayor of Seattle, and has three objectives:

1. “Urge the federal government and state governments to enact policies and programs to meet or beat the target of reducing global warming pollution levels to 7 percent below 1990 levels by 2012”

2. “Urge the U.S. Congress to pass bipartisan greenhouse gas reduction legislation that 1) includes clear timetables and emissions limits and 2) a flexible, market-based system of tradable allowances among emitting industries”
3. “Strive to meet or exceed Kyoto Protocol targets for reducing global warming pollution by taking actions in our own operations and communities” (23)

The last objective is the most significant because it specifically calls for signatories of the Agreement to reduce emissions in their cities 7% below 1990 levels by 2012. Much like the Kyoto Protocol, the Agreement does not dictate how or where emissions cutbacks should take place, but many of the cities are looking toward transportation to see some reductions. In fact, the Agreement document itself identifies several example transportation strategies (among strategies of other sectors) that would prove effective, including:

- “Adopt and enforce land-use policies that reduce sprawl, preserve open space, and create compact, walkable urban communities”
- “Promote transportation options such as bicycle trails, commute trip reduction programs, incentives for car pooling and public transit”
- “Increase the average fuel efficiency of municipal fleet vehicles; reduce the number of vehicles; launch an employee education program including anti-idling messages; convert diesel vehicles to bio-diesel” (23)

It should be reiterated that the Agreement is voluntary and the Kyoto-inspired reduction targets are not enforceable. But while the Agreement may not have regulatory force behind it, the significance of its successful adoption across the country (852 cities and counting (24)) indicates that communities are actively engaging in greenhouse gas

mitigation efforts despite a lack of federal involvement. Clearly the need and support for transportation-related mitigation strategies exists in the U.S. The remainder of the literature review explains the mitigation strategies of Figure 2.2 in more detail.

2.2.1 Vehicle and Network Efficiency

A common and effective strategy to reduce greenhouse gas emissions is to improve the efficiency of transportation systems, namely the vehicles themselves and the network on which they operate. Regulating vehicle efficiency, denoted by miles per gallon (mpg), is largely a function of the federal government⁸ through advancements of the Corporate Average Fuel Economy (CAFE) standards. In comparison with the rest of the developed world, the U.S. has the lowest fuel economy standards (25). But as part of *The Energy Independence and Security Act of 2007* (EISA), CAFE standards will rise to 35 mpg by 2020 (26), which will no doubt play a crucial role in mitigating climate change. In terms of vehicle efficiency, metropolitan and local strategies, aside from advocating for tougher CAFE standards, are non-existent due to the large administrative and regulatory framework required to implement changes in fuel economy.

On the other hand, MPOs and local governments may work to increase the efficiency of the transportation network to provide greenhouse gas savings. The *Climate Action Program at Caltrans* identifies operational improvements as well as intelligent transportation systems (ITS) as effective emissions reduction strategies (27). A study concerning Canadian transportation found that addressing network efficiencies such as ITS, traffic signal synchronization, speed limit enforcement, and high occupancy vehicle

⁸ The *Clean Air Act* also allows California to create its own emissions standards, but the EPA denied the state's waiver in December 2007. California is now suing the EPA, citing the recent Supreme Court case of *Massachusetts v. EPA* that states CO₂ qualifies as a pollutant.

(HOV) lanes could potentially save 6.5 Mt of CO₂ equivalent (6,500,000,000 kg CO₂ equivalent), or approximately 12% of total Canadian reductions required for Kyoto compliance (13).

2.2.2 Carbon Intensity of Fuels

In addition to vehicle technology and transportation network efficiency, greenhouse gas emissions are also a function of the different types of fuel. For example, more CO₂ is emitted per mile from gasoline than from B100 (100% biodiesel). Table 2.1 demonstrates the differences in bus emissions per fuel type, represented by tailpipe emissions only.

Table 2.1: Bus emissions per fuel type (28)

Fuel Type	Bus Emissions (lb CO ₂ /mile)
Gasoline	16.1
Petroleum Diesel	13.3
Compressed Natural Gas	11.7
B20 (20% Biodiesel/80% Diesel)	11.5
Ethanol from Corn	11.0
Hydrogen from Natural Gas	7.3
B100 (100% Biodiesel from Soy Beans)	3.7
Hydrogen from Electrolysis	1.3

Fuel standards are a function of the federal or state government and are also addressed within *The Energy Independence and Security Act of 2007*. The act calls for biofuel production to grow to 36 billion gallons by 2022, representing a 666% increase from 2007 (26). But while the tailpipe emissions may be less, life cycle greenhouse gas emissions from biofuels could actually be higher than gasoline based on a variety of factors such as land use changes, manufacturing processes, and the amount of energy input required (29). Provided that life cycle greenhouse gases can be reduced or

prevented, biofuels may provide useful mitigation potential. Metropolitan and local strategies to address carbon fuel intensity are limited. A common strategy is to introduce fuels of less carbon intensity into municipal and transit fleets (28), essentially increasing awareness to the general public of their existence.

2.2.3 VMT Reduction

Vehicle-miles traveled hold a positive relationship with the magnitude of transport-related carbon emissions because greenhouse gas is a byproduct a vehicle's internal combustion engine. In other words, the more one drives the more one contributes to climate change. More efficient surface transportation and fuels of lower carbon intensity certainly help reduce the rate of greenhouse gas emissions on a per mile driven basis, but trends and projections show that rapidly increasing VMT have "overwhelmed" any efficiency gains (8, 20). This means that emissions from transportation are expected to rise from current levels even with new CAFE and low carbon fuel standards⁹ (20). Technology alone cannot fully mitigate the worsening of climate change. Further opportunities may lie in strategies that achieve VMT reductions through travel demand management (TDM). TDM is a planning or policy technique that seeks to discourage automobile use in favor of other, more efficient transportation modes. With respect to climate change, the most common strategies to control and reduce VMT through TDM are providing transportation alternatives, influencing transportation pricing, and managing land use.

The latest IPCC document declares "modal shifts from road transport to rail and public transport systems [and] non-motorised transport (cycling, walking)" are important

⁹ Analysis from *Growing Cooler* assumed a nationwide adoption of California's Low Carbon Fuel Standards

strategies that can provide opportunities to further mitigate the effects of climate change (1). Telecommuting, working from home instead of an office, eliminates work trips completely and is thus considered an important concept of transportation related greenhouse gas reduction (8, 13, 30). Providing transportation alternatives to automobiles is considered a step in the right direction to reducing greenhouse gases for several reasons:

- Enables more efficient land use through higher densities (discussed later)
- Shared rides can emit less greenhouse gas per person than single occupant vehicles
- Bicycles, walking, and telecommuting emit no greenhouse gas
- Rail transit powered by electricity

There are caveats with some of these assumptions:

1. Buses may not provide better per person emission rates if there is not sufficient ridership, depending on the fuel (see Table 2.1 for fuel comparison). The reason for this is that buses are more energy intensive vehicles relative to rail-based alternatives because of their friction with the pavement and high frequency of stops (constant acceleration). It would take more passengers in a bus than in a rail car to emit less greenhouse gas per person compared to driving alone. If there is a lack of ridership, buses may actually produce more greenhouse gas per person. With this in mind, it may be unsurprising that the Melbourne, Australia, City Council does not recognize the bus as a sustainable transportation option for the long-term (31). However, buses in the future that operate on hydrogen or B100 fuel may rectify this issue, provided total life cycle greenhouse gases can be

reduced or prevented.

2. The majority of rail transit is powered by electricity (aside from diesel-powered commuter trains), which produces no tailpipe emissions. Greenhouse gases are instead most likely produced upstream at a coal burning power plant. With increasing development of alternative energy sources (wind, solar, biomass, etc.) and carbon-capturing technology, rail has the potential to be almost¹⁰ carbon-free.

Even with these caveats, VMT reductions result from transit availability coupled with higher densities. Studies have shown that each passenger mile of transit is equivalent to multiple passenger miles of driving an automobile, suggesting there are greenhouse gas savings associated with riding transit (28). An analysis conducted by the American Public Transportation Association (APTA), and cited in *TCRP Report 93*, demonstrates CO₂ savings in three case study areas (District of Columbia, Los Angeles, and Chattanooga, Tennessee) due to public transportation. APTA calculated the total CO₂ emissions of transit (rail, bus, and demand response) during 1999 from the study areas and calculated the amount of CO₂ savings as if each transit trip had replaced equivalent automobile trips. Table 2.2 highlights the results, and the methodology for this calculation is located in Appendix A of *TCRP Report 93*.

Table 2.2: “Comparative emissions from public transit and replacement use of private vehicles” (28)

Mode of Travel	Metric Tons of CO ₂ in 1999
Public Transit	9,120,489
Private Vehicles	16,526,345
Environmental Savings	7,405,856

¹⁰ Presumably, greenhouse gases from manufacturing rail cars would still exist.

These greenhouse gas savings are very encouraging, but for many people the choice to utilize an alternative form of transportation has more to do with economics than being environmentally conscious. Using transportation alternatives can often save money, whether from a policy decision (e.g. carpooling over the San Francisco-Oakland Bay Bridge to skip the toll) or even free market forces (e.g. riding commuter rail to save from expensive parking prices in Manhattan). Planners and policy makers are beginning to understand the concept of pricing and use it to either heighten the attractiveness of alternative transportation and reduce VMT or provide increased capacity to congested urban roadways. For the purpose of reducing VMT and greenhouse gases, pricing automobile use through usage fees, or creating a disincentive to drive, is seen as an effective strategy in lowering VMT and encouraging transportation alternatives (1, 13, 28). However, all pricing mechanisms are not disincentives by nature since some policies provide incentives to use alternative transportation or carpool. Some examples of pricing strategies at the metropolitan and local level and from both ends of the incentive spectrum include:

- **Congestion charge:** A congestion charge is a method of pricing vehicle access to a congested area, most likely in a congested city, which is designed to reduce traffic volumes. The most famous example of a successful congestion charge zone is in London where vehicle users must pay £8 per day to access the greater downtown area by vehicle. Since inception in 2003, the London Congestion Charging Zone has cut traffic by 21% from 2002 levels and has resulted in increased cycling and transit use (32). A more expensive charging scheme (£25 per day) aimed at vehicles emitting high amounts of CO₂ is being planned for the

zone (33).

- **Higher parking rates:** Increasing parking costs are expected to reduce greenhouse gas emissions to a large degree, but the strategy is thought to only be effective in conjunction with complementary mitigation strategies (13). Parking management is discussed later with land use.
- **Advocating for pay-as-you-drive (PAYD) insurance:** PAYD pricing schemes attempt to reveal the true cost of driving by charging on per mile or per unit time basis. By paying a variable cost linked to automobile usage, VMT is expected to decline (34). Implementing PAYD policies require the administrative capabilities of state and federal government, leaving the role of MPOs and local governments to that of advocate. Five states are currently investigating PAYD insurance policies (35).
- **High occupancy toll (HOT) lanes:** HOT lanes are high occupancy vehicle lanes that dynamically or statically price any remaining capacity for use by single occupant vehicles. HOT lanes are tools to increase the capacity and improve operations of congested highways. Their greenhouse gas reduction potential, however, is mixed. A smoother traffic flow would theoretically produce fewer emissions if traffic volumes stayed constant, but the increase of capacity may actually encourage more highway users and increase the total emissions. A projection study for the SR 167 HOT lanes in Seattle, Washington, showed that traffic flows in both directions are expected to rise because of better roadway efficiency (36). Additionally, HOT lanes are generally billed as a method to provide improved transit and carpool reliability, but a study conducted over the

first year of operations of Minneapolis' I-394 HOT lane system showed the transit and carpool level of service (LOS) remained unchanged (37). Still, new HOT lanes are moving forward as effective emissions reduction tools (38).

- **Parking cash out:** Employers often offer subsidized parking spaces to employees as a perk. Parking cash out programs give employees a choice to refuse a parking spot in favor of cash or a subsidized transit pass of equal value. Cash out programs have been shown to decrease vehicle travel and increase use of alternative modes of transportation. For example, a study by Donald Shoup for the Transport Policy Journal investigated the outcome of California's parking cash out program for almost 1,700 employees across 8 different companies. The results showed that driving alone dropped by 17%, while carpooling increased by 64%, transit increased by 50%, and walking or cycling increased by 39% (39). VMT of the commutes to work fell 12% and CO₂ emissions dropped 367 kg per employee for the year (39).

Other, non-pricing metropolitan and local strategies that encourage alternative transportation and lower VMT and greenhouse gases include:

- **Environmental zones:** Many European cities are implementing and finding success with environmental zones, which are access restrictions that prohibit heavy and polluting vehicles from entering certain areas, usually city centers (30). Cities either considering or already have environmental zones include Prague, Stockholm, Malmö, Gothenburg, Rome, Berlin, and London (30).
- **Commuter benefits** such as guaranteed ride home from work programs and transit fare reductions.

- **Ridesharing services**

But of all the strategies to reduce VMT, perhaps the most effective, yet most difficult to implement, is to modify local land use ordinances to encourage compact development patterns, otherwise known as smart growth. Smart growth is commonly presented as the antithesis to unplanned suburban sprawl. The concept incorporates many aspects of community development and accessibility that are designed to discourage automobile travel, thereby reducing VMT. Table 2.3 is a comparison between generalized characteristics of smart growth and sprawl adapted from the literature (20).

Table 2.3: Comparison between sprawl and smart growth

Characteristic	Sprawl	Smart Growth
Zoning	Single use	Mixed use
Density	Low	Medium - high
Development	Strip; New development on cheaper, exurban land	Centered; Inward development; Brownfields
Street Patterns	Cul-de-sacs force traffic onto overused arterials; Low connectivity	Grid; High connectivity
Accessibility	Auto-dominant; Transit often not feasible	Transit supportive; Walking and cycling friendly
Parking	Abundant	Limited

Though generalized, the side-by-side comparison of Table 2.3 is revealing. Automobile use is so high in sprawling communities because there is usually no other realistic option. Low-density development, single use zoning, poor street connectivity, and abundant parking not only ensure that walking and cycling are unsafe but public transportation is almost entirely ineffective in competing with the automobile. Reducing VMT and greenhouse gas emissions in such a sprawling environment without addressing

land use would be entirely dependent on new vehicle and fuel technology, but a common understanding is that such a scenario is not possible due to rapid growth in VMT (8, 20).

Sizeable VMT growth within the U.S. is largely a result of the sprawling, outward expansion of the nation's population centers; its metropolitan areas. Growth of metropolitan land consumption is outpacing growth of metropolitan population in all portions of the country. In the northeast alone, land consumption outpaces population growth by a factor of 5 (20). To demonstrate the relationship between higher VMT and sprawling lifestyles, a comparison between the ten most sprawling and compact metropolitan areas showed that, on average, VMT per capita was 22% less in compact metropolitan areas (27 VMT per day per capita versus 21) (20). For these reasons, linking transportation planning with land use is considered not only necessary but also a promising technique in mitigating the magnitude of climate change (1, 13, 23). For example, the *Climate Action Program at Caltrans* estimates that smart growth alone could reduce per capita VMT by 10-30% in the state (27), while another report suggests smart growth has the potential to reduce end-year greenhouse gases by 7-10% below expected levels by 2050 (20).

The potential for meaningful greenhouse gas reductions through smart growth is almost certain, but the problem lies in coordinating those in charge of transportation planning (federal government, state, and MPO) with those in charge of land use planning (local governments) (27). To improve coordination, closer working relationships and aligned goals and objectives between state, regional, and local governments and organizations are a must. California has recently developed a promising approach to facilitating smart growth strategies at all levels of government. Known as the California

Regional Blueprint Program, the approach aims to provide a “framework for the state, local and regional agencies and the community to agree on long-term, land use patterns and transportation systems that improve mobility through smart land use measures” (27).

Policy changes that allocate funding to transportation and smart growth projects that demonstrate greenhouse gas reductions are also needed at the federal level (20).

Examples of strategies at the metropolitan and local level include:

1. "Change the development rules to modernize zoning and allow mixed-use, compact development;
2. Favor location-efficient and compact projects in the approval process;
3. Prioritize and coordinate funding to support infill development;
4. Make transit, pedestrians, and bikes an integral part of community development;
5. Invest in civic engagement and education." (20)

2.2.4 Government Policies and Programs

The final general mitigations strategy is the enactment and enforcement of various governmental policies and programs that attempt to lower greenhouse gas emissions.

Thus far in the U.S., most policies at the national level have failed to pass through congress, with the exception of the EISA in 2007. Still, there are a variety of potential policies and programs at the national or state level that could reduce greenhouse gas emissions, though passing such strategies is clearly a politically contentious issue.

According to the European Council of Ministers, government policies or programs are often the most cost-effective mitigation strategies available (22). Furthermore, the European Council of Ministers has recommended several mitigation policies and programs to European Union members, such as:

- “Reform of vehicle taxation (purchase, registration and annual circulation taxes), so that it is based on a vehicle’s specific CO₂ emissions”
- “Regulatory standards can be designed to steer consumers and manufacturers to the better performing components [tires, air conditioners, alternators, lubricants and lights] at low cost and can be designed also to promote technological improvement”
- “Tax incentives can be used to complement standards”
- “Initiatives to promote fuel efficient driving, particularly through training programmes [sic] for both car and truck drivers offer significant cost-effective savings”
- “Fuel taxes and emissions trading” (22)

2.3 Summary

From a transportation perspective, there are many strategies available to adapt to or mitigate the effects of climate change. However, not all are applicable at the metropolitan and local level. Adapting transportation infrastructure and operations to the effects of climate change is best accomplished with a selective risk management framework. The framework is compatible (7) with the conceptual transportation planning framework that will be discussed in the next section. In terms of mitigating greenhouse gases, regulations of vehicle technology and fuel standards as well as other government policies and programs would be taken care of at the federal or state level, leaving little in the way of metropolitan or local involvement. Strategies for MPOs and local governments are best suited for attempting to reduce VMT with alternative transportation, pricing and incentives, and coordinated land use planning. Increasing the

operational efficiency of the transportation network through ITS, signal synchronization, and HOV/HOT lanes are also viable strategies. With the defined roles and responsibilities established for the metropolitan and local level, the next chapter will explain the conceptual transportation planning framework.

CHAPTER 3

CONCEPTUAL FRAMEWORK

The adaptation concept and mitigation strategies discussed in the literature review are important in addressing climate change, but they are merely pieces that fit into the much larger transportation-planning framework. The conceptual transportation planning framework, shown in Figure 3.1, is known for its ability to adapt a variety of considerations into the transportation planning process, such as environmental and safety concerns (40, 41) or, in this case, climate change (7). The framework provides a simplified outline of the comprehensive planning process in broad terms. As stated in NCHRP Report 541, the framework is general enough to describe planning at both the state and metropolitan level (40), but for the purpose of this report it is meant to represent planning at the metropolitan and local level only. The remainder of this report investigates metropolitan planning organizations and domestic and international cities to determine how well climate change considerations have been incorporated into transportation planning. The framework shown in Figure 3.1 is used as an organizing concept for describing key components of the planning process. The following outline of the planning components is adapted from NCHRP Report 541, *Consideration of Environmental Factors in Transportation System Planning*.

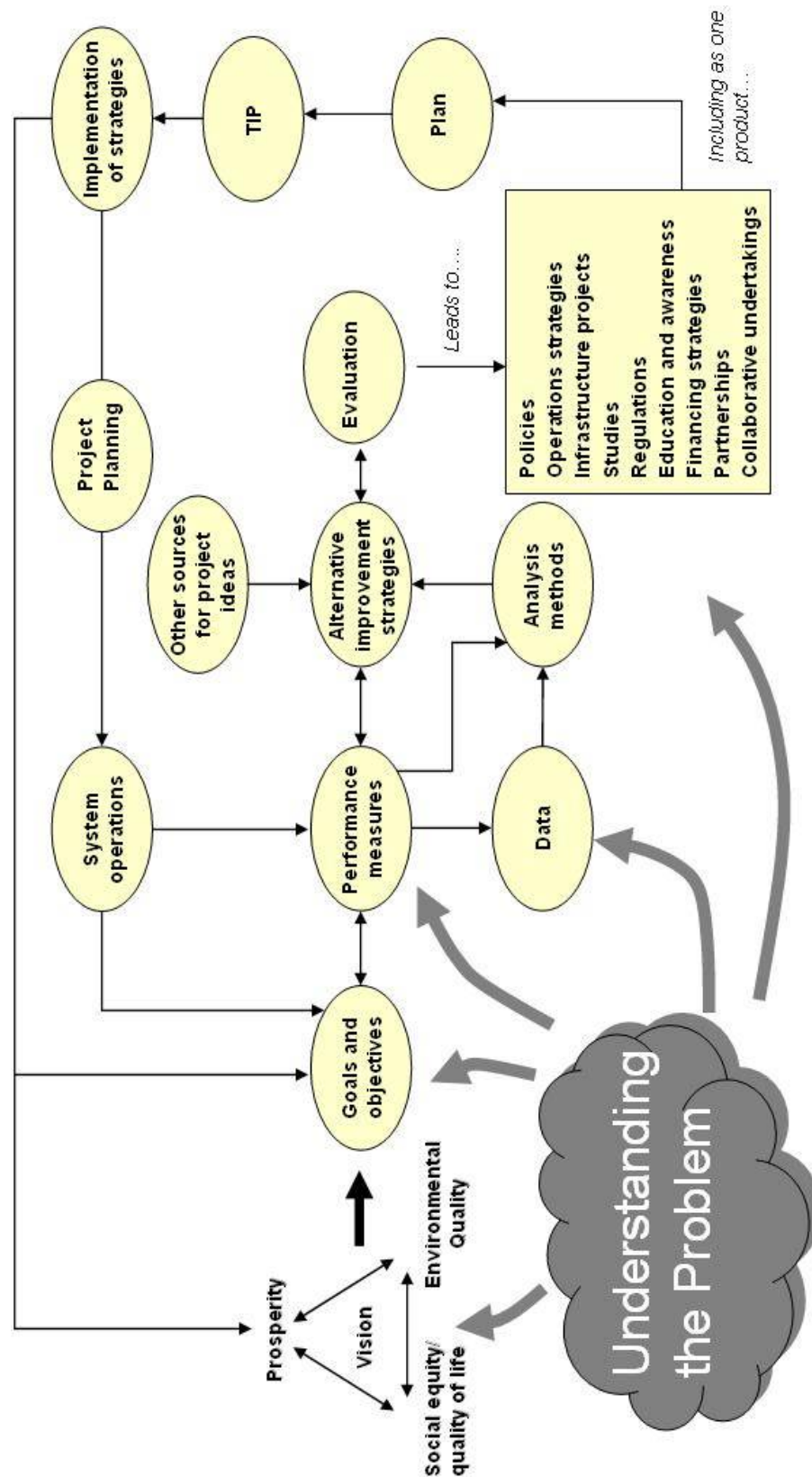


Figure 3.1: Conceptual transportation planning framework (42)

3.1 Conceptual Framework Outline

The creation of a vision is the first step of the conceptual framework. The vision represents a confluence of desired outcomes as decided by planners, politicians, and the general public through a visioning process. Vision statements may have varying degrees of specificity from one organization to another, depending on the planning scope of an organization. For instance, an MPO is more likely to have a more detailed vision than a state department of transportation due to differences in roles and responsibilities. Figure 3.1 demonstrates what the constituents of a sustainability vision may look like; however, other considerations, such as climate change, could be represented in the vision stage if so desired by the organizations and communities involved.

A vision can direct an organization around common concepts, but fine-tuning that vision statement into precise goals and objectives provides the general direction for an organization's planning process. If a vision is the desired outcome, the goal would be the required target to achieve the vision and the objective would be the precise action necessary to meet such a goal. For example, if an MPO's vision is to reduce its area's carbon emissions, a goal may be to lower greenhouse gas emissions to 80% below 1990 levels by 2050 with an objective of reducing VMT by 80% during the same time period. In addition to narrowing a vision's focus, goals and objectives lead to the development of evaluation criteria later in the planning process and system performance measures in the next step.

Utilizing performance measures to assess the functioning of important transportation systems is a recent occurrence within transportation planning. Such measures are critical in determining the types of data required for such assessments.

Performance measures that detect changes in “congestion, averages speeds, system reliability, and mobility options” are common, but other measures, such as for “environmental quality, economic development, and quality of life,” remain underused (40).

Data from performance measures are fed into the analysis portion of the conceptual framework. Analysis is a crucial step in the framework because it explores the relationships of various planning concerns that affect transportation systems and investigates how changes influence future performance. Alternative strategies, such as TDM and ITS measures, are identified during this step, and the tools used during the analysis, such as simulation model software, create information for the evaluation step.

Evaluation is pulling together all available analysis on the positives and negatives of alternatives so strategies that best address the vision, goals, and objectives are included in the resulting transportation plan. Characteristics of evaluation are described in NCHRP Report 541:

- “Focus on the decisions being faced by decision makers.
- Relate the consequences of alternatives to goals and objectives.
- Determine how different groups are affected by transportation proposals.
- Be sensitive to the time frame in which project effects are likely to occur.
- In the case of regional transportation planning, produce information on the likely effects of alternatives at a level of aggregation that permits varying levels of assessment.
- Analyze the implementation requirements of each alternative.
- Assess the financial feasibility of the actions recommended in the plan.

- Provide information to decision makers on the value of alternatives in a readily understandable form and a timely fashion.” (40)

Once the evaluation process is concluded, the outcome is the identification of recommended strategies, otherwise known as the plan.

The process of selecting projects for the transportation improvement program (TIP) based on positive evaluation is known as programming. Due to budget and resource restrictions not every project that reflects the goals and objectives may be put on the TIP. Allocating funds by project priority is the common solution to addressing monetary constraint in project development. The priority process may resemble an objective procedure of weighing costs and benefits of projects relative to each other or it could be subject to political influence.

Now that the planning process has identified a set of projects that best meet the area’s goals and objectives, a more detailed project development process will usually take place. This process finalizes and polishes projects in terms of design and operations before they are implemented. Project development can vary according to the scope of a project. For instance, synchronizing traffic signals might require simulation software that can be utilized fairly quickly, while implementing a commuter benefits program would require a concerted public outreach effort that would include marketing to the general public and metropolitan businesses. The final step, system monitoring, completes the loop of the conceptual framework by providing feedback to the vision, goals and objectives, and performance measures. The next iteration of the planning process (as noted by the feedback loop in the conceptual framework) would ideally take into account the results of system monitoring. In this way, the planning process remains relevant to

transportation issues and process modifications can be made to improve planning's overall effectiveness.

3.2 Conceptual Framework Application

In order to investigate current efforts to incorporate climate change considerations into the transportation planning process, a review was conducted of available online material cities (such as long-range plans, TIPs, other relevant documentation) for a set of MPOs and domestic and international. No surveys or employee interviews were conducted due to time constraints. This section of the report applies the material obtained in the review that is pertinent to climate change to specific steps of the conceptual framework.

The selection process for identifying candidate areas was straightforward. For MPOs, the largest 75 cities in the United States were considered. Because some MPOs contain multiple large cities, 60 unique MPOs were reviewed for this research. Each MPO that discussed climate change or global warming within its plans is qualitatively summarized in the appendix. Material that stood out with respect to both specific steps of the conceptual framework and climate change are presented in more depth in this section of the report. Domestic and international municipal transportation planning efforts relating to climate change are summarized in the appendix as well. For these cities, an Internet search using various search engines was carried out to find locations where climate change is discussed within the context of transportation planning. In all, 13 domestic and 27 international cities are summarized. Google's translation software¹¹ was used when international information was not in English. As expected, the most abundant

¹¹ http://translate.google.com/translate_t

information was found in cities that primarily speak English or publish documentation in English.

3.2.1 Vision

3.2.1.1 Boston Region Metropolitan Planning Organization (43)

Much like the City of Boston itself, the Boston Region Metropolitan Planning Organization (BMPO) contains a large percentage of the state's population (48%) relative to its size (18%). The BMPO covers a dense region of 101 cities and towns in an area of approximately 1,405 square miles. With so many cities and towns within the planning region, competing interests and differing opinions no doubt make public outreach a challenging task, but the BMPO has made public participation a major component in the development of its most recent long-range comprehensive transportation plan, *Journey to 2030*.

Members of the public were invited to join in the plan development process through open houses, regional forums, workshops and other meetings during the creation of the draft plan throughout 2005 to 2007. Outreach was not only focused on traditional participants such as residents, businesses, and government officials, but also on those typically not involved in the planning process, for instance those who may not speak English, minorities, low-income earners, and the disabled. Methods of communication included e-mail, newsletters, and the Internet.

Public comments were recorded and taken into consideration during the development of many aspects of the plan, including the guiding principles. Though many comments were recorded by BMPO over the course of 16 months, concerns of climate change and the emissions of greenhouse gases were evident. The final visions and

policies of the plan reflect these concerns. Portions of the environmental vision and policy statements read:

“*Vision:* Transportation planning activities and projects will strive to reduce air quality degradation and other environmental degradations caused by transportation. Vehicle emissions (carbon monoxide [CO], nitrogen oxides [NO_x], volatile organic compounds [VOCs], particulates, and carbon dioxide [CO₂]) will be reduced by modernizing transit, truck, and automobile fleets, and through increasing transit mode share.”

“*Policy:* To minimize transportation-related pollution and degradation of the environment; promote energy conservation; support the preservation of natural resources and community character; and advance sustainability, regional environmental benefits, and health-promoting transportation options, the MPO will:

- Give priority to projects that maintain and improve public transportation facilities and services so as to increase public transportation mode share and reduce reliance on automobiles.
- Give priority to projects that reduce congestion or manage transportation demand to improve air quality.
- Support, through planning and programming, projects that make transportation in the region more sustainable.
- Promote the use of low-polluting or alternative fuels, efficient engine technology, and other new, viable technologies that protect resources.
- Consider environmental issues during project selection; in particular, air quality and the reduction of pollutants (CO, NO_x, VOCs, particulates, and CO₂), the

protection of water resources (soil and water contamination, stormwater management, and wetlands impacts), greenfields and open space, and wildlife and ecosystem preservation; and value those projects that reduce negative impacts.

- Encourage, through planning and programming, transportation choices that promote a healthy lifestyle such as walking and bicycling.”

The vision and policy statements may have had other influences as well. The plan later discusses Governor Patrick’s joining of the Regional Greenhouse Gas Initiative in January 2007 and the Supreme Court case *Massachusetts v. EPA*. Immediately following the discussion is a pledge by BMPO to “continue to support projects and programs that reduce emissions of CO₂ in the region.”

Another set of vision and policy statements are concerned with linking land use and transportation decisions, which is federally mandated and, subsequently, common among all MPOs. Land use planning is an important component of mitigating greenhouse gases, as identified earlier in this report, but most MPOs are not framing the land use and transportation linkage from a climate change or CO₂ perspective. While the BMPO is not necessarily framing its land use vision in such a manner either, the linkage is still noteworthy in the sense that CO₂ is included in the organization’s emissions analysis.

3.2.1.2 City of Boston, Massachusetts (44)

The process for developing a vision to address climate change is different for cities and MPOs. An MPO operates on the foundation of a collaborative planning process, and the federal government, while extremely influential in guiding an MPO’s operations, does not mandate that climate change or greenhouse gases should be part of

its policies and vision. In many cities, however, the need to address climate change actually arises from an executive order by the chief executive of the city, most usually the mayor. Boston, for example, is one such city.

The Mayor of Boston, Thomas Menino, signed an executive order, *An Order Relative to Climate Action in Boston*, on April 17th, 2007. Inspiration for the order came from the U.S. Mayors Climate Protection Agreement and the ICLEI—Cities for Climate Protection campaign. In addition, the effects of climate change on infrastructure, among other categories, from sea-level rise, heat waves, flooding, and increased storm severity serve as the reasoning behind the order. The order identifies general strategies that would later be reflected in the creation of a climate action plan to combat climate change from various sectors. Transportation is a recurring theme in several strategies including increasing energy efficiency, reducing emissions, and “improv[ing] transportation and other infrastructure.”

This example of visioning in a climate action plan is not unique to Boston. Many other cities have created climate action plans in response to their respective executive orders as well. Most climate action plans are generally similar, though they differ from long-range transportation plans developed by MPOs. A long-range MPO plan represents a planning process where reducing greenhouse gases may be but one component of a much broader vision, but a climate action plan is just what it sounds like—a plan of specific actions tailored to reduce greenhouse gases and curb the effects of climate change through various sectors, such as transportation, municipal operations, private businesses, and energy production. Consequently, some aspects of the transportation planning process are either not present or not as developed within a climate action plan.

3.2.1.3 City of Seattle, Washington (23, 45)

Greg Nickels, the Mayor of Seattle, has arguably had the greatest impact on a national vision to address climate change than any other person. Mayor Nickels created the US Mayors Climate Protection Agreement in 2005. The agreement, previously introduced and discussed in detail in the literature review, continues to gain support from mayors across the country. Figure 3.2 shows the locations of all 852 cities (as of 5/22/2008) that are now a part of the program and have pledged to reduce their greenhouse gas emissions to meet the Kyoto Protocol reduction goal of 7% below 1990 levels by 2012. Seattle has also developed its own climate action plan that focuses on mitigation strategies, but the plan states that climate adaptation strategies are currently in development.

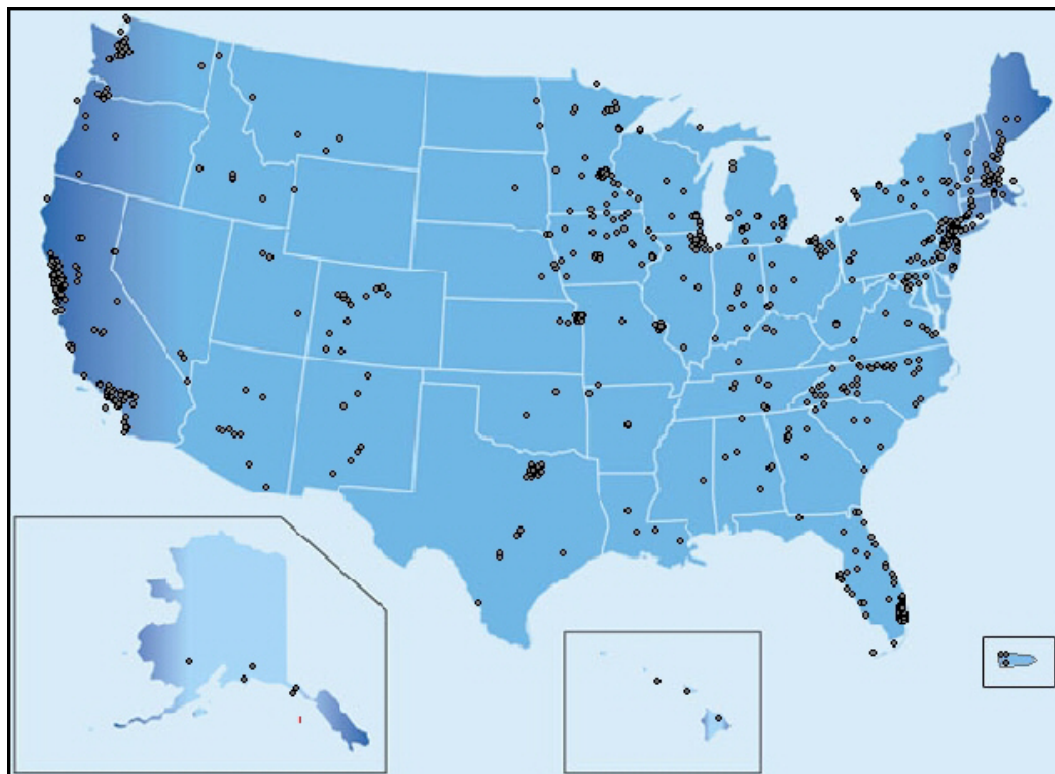


Figure 3.2: Locations of all US Climate Protection Agreement signatory cities (46)

3.2.1.4 Chicago Metropolitan Agency for Planning (47, 48)

The Chicago Metropolitan Agency for Planning (CMAP) acts as both the MPO and regional land use planning organization for the seven-county Chicago metropolitan area. The CMAP was created in 2005 by combining the former MPO, the Chicago Area Transportation Study, and the former regional planning organization, the Northeastern Illinois Planning Commission, in order to better integrate the planning of land use, housing, economic development, transportation, and environmental considerations. The agency is presently undergoing planning and development of its first true integrated regional plan, *Go To 2040*.

A portion of crafting *Go To 2040* is dedicated to identifying and defining the plan's regional vision through public participation. The CMAP created draft vision statements that were reviewed during a "visioning event." Attendees of the event recorded their reactions to the statements via keypad polling. Opinions of the statements were then updated in response to the views of those polled. The vision statements were grouped into 14 focus areas and three reactions were available during polling: positive, neutral, or negative. Several of the initial draft vision statements related to greenhouse gases and transportation, with accompanying reaction scores and updated statements, include:

- "Sustainability
 - Statement from Visioning Event: The region will actively mitigate the effects of its activities on the environment, including climate change and will be prepared to adapt to the likely effects on the environment.
 - **Keypad polling results:**

Neutral. 30% positive, 53% neutral, 18% negative

- New Vision Statement: The region will actively mitigate the environmental effects of its activities—including climate change—and will be prepared to adapt to future environmental conditions.”
- “Energy and Resource Conservation
 - Statement from Visioning Event: Shift energy use to sources which are low or no-eco footprint and provide transportation options and a work/play/shop paradigm to create lower overall impact (eco, time, cost, herd mentality)
 - **Keypad polling results:**

Neutral. 24% positive; 55% neutral; 21% negative
 - New Vision Statement: Abundant transportation options, mixed use infill development, and a balanced supply of jobs and housing will reduce pressure to develop in environmentally sensitive areas and will reduce regional energy consumption.”
- “Economic Competitiveness
 - Added Vision Statement: Our farmland, which is among the most fertile in the nation, will be valued as an important regional resource because of the economic contribution it makes, the food and fuel it produces, the scenic value it provides, and the soil and water it protects.”

For the most part, these new vision statements are fairly similar to the statements from the visioning event, except that they have a more refined emphasis. It is interesting to see that biofuels production is addressed in the vision statements, but not surprising

considering the profitability of ethanol production. The next step for the vision statements is to undergo further refinement from working committees and further commenting via paper and electronic survey. To further reinforce climate change into the visioning process, the CMAP held a climate change summit, titled *Innovation + Integration: Creating a Regional Agenda to Address Climate Change*, with the intent of developing a regional climate change agenda for *Go To 2040*. It is unclear whether such an agenda has been formulated at this point.

3.2.1.5 New York Metropolitan Transportation Council (49, 50, 51, 52)

The New York Metropolitan Transportation Council (NYMTC) holds the distinction of being the most populated MPO in the country with 11.3 million people, or 65% of New York State's total population, within its geographic boundaries (lower Hudson Valley, New York City, and all of Long Island). Consequently, the New York City region, and especially New York City itself, has some of the highest population densities in the U.S., which, in turn, translates into extremely high rates of walking and public transportation use. Alternative transportation use is so high in the region that New York City inhabitants alone consume 40% less energy than the average U.S. citizen. Not content with such relatively low rates of energy use, NYMTC is committed to further address energy use and greenhouse gas emissions in its most recent long range plan, *2005-2030 Regional Transportation Plan*.

In defining its principles, the NYMTC compiled a list of three overarching trends and issues that influence the transportation planning process in the region: environmental quality, energy, and economic vitality. Each main category contains several statements

that further define the issue, with both the environmental quality and energy categories containing relevant climate change statements:

- “***New York State Greenhouse Gas Reduction*** –In recognition of the role of transportation in reducing greenhouse gases in possible climate change scenarios, New York State’s Energy Plan highlights the levels of greenhouse gas emissions in the region and the steps that must be taken to reduce them.”
- “***New York State Energy Plan*** – New York State’s Energy Plan recognizes the contribution of the transportation sector to overall energy consumption and encourages increased efficiency and reduced dependence on fossil fuels.”

As is evident, the *New York State Energy Plan* frames the issues of greenhouse gases and energy consumption for the NYMTC. The plan, adopted in 2002, recommends the usage for clean, renewable, and alternative energy to help satisfy the state’s energy demand. Transportation considerations play a key role in the plan. The plan features 15 major policy strategies, including several that influenced the NYMTC’s overarching issues and trends section:

- “The State adopts the goal of increasing renewable energy use as a percentage of primary energy use 50%, from 10% of primary energy use currently, to 15% by 2020.”
- “The State adopts the goal of reducing greenhouse gas emissions 5% below 1990 levels by 2010, and 10% below 1990 levels by 2020.”
- “The State will continue its efforts to reduce traffic congestion and delays and increase energy efficiency in transportation through a complement of actions that include supporting public transit, transportation management, intelligent

transportation systems, and capital construction.”

The NYMTC is now in the process of updating its transportation plan for the horizon years of 2010-2035. The draft overarching trends and issues for the update are more robust than the original plan and feature five categories: economic innovation and technology change, lifestyle and workforce change, globalization and security, energy and climate, and transportation financing. The recurring identification in the NYMTC’s plans of climate change as a serious issue demonstrates the importance of greenhouse gases to the well-being of the region. The draft plan states that “the convergence of these major trends in energy and climate will have serious implications for the region and its transportation system” and that “transportation supply can also be impacted by climate change, as infrastructure is damaged or destroyed by catastrophic weather events and/or rising sea levels.”

3.2.1.6 Portland Metro (53)

Metro is more than an MPO for the Portland, Oregon region. The organization is actually an elected regional government that focuses on urban growth strategies, transportation planning, waste management, and even operates the Oregon Zoo in western Portland. Because of Metro’s wide-ranging nature, it may come as no surprise that the Portland region is famous among planners for its growth vision to limit sprawl through urban growth boundaries while successfully linking transportation and land use planning through infill and brownfield developments. The Portland region, as well as the Pacific Northwest in general, is also known for its environmental consciousness, which is reflected in the *2035 Regional Transportation Plan*.

In the *Challenges and Opportunities* chapter of the plan, climate change is identified as a key challenge of the regional transportation system. Climate change is viewed as a challenge from both mitigation and adaptation perspectives. The plan alludes that mitigation efforts will be necessary to combat greenhouse gas emissions, especially since the Oregon Department of Transportation predicts that VMT across the state will increase 33% by 2025. Much like in the New York City region, Metro cites greenhouse gas legislation at the state level as an influence on the plan. Metro then states that while no greenhouse gas standards have been specified, it will voluntarily keep track of emissions and present trends in future plan updates. Potential consequences of climate change to transportation infrastructure are also discussed as a key challenge, but the plan states that “more research is needed to better understand the long-term affects [sic].” In addition, the *2035 Regional Transportation Plan* is designed to support the concepts of the region’s growth plan, known as the *2040 Growth Concept*. The transportation plan cites several broad benefits in assisting the vision of the *2040 Growth Concept*, including a “reduction in emissions of greenhouse gases and reduced per person consumption of oil for transportation.”

3.2.2 Goals, Objectives, and Performance Measures

3.2.2.1 Boston Region Metropolitan Planning Organization (43, 54)

There are many people and agencies that contributed to the development of the BMPO’s long-range transportation plan, *Journey to 2030*. The Massachusetts Bay Transportation Authority (MBTA) contributed directly with its *Program for Mass Transportation* (PMT), most recently updated in 2003. The PMT is part of the MBTA’s capital planning process, where system expansion and service projects are evaluated

against 35 performance measures relative to the program's goals and objectives (which are "consistent" with *Journey to 2030*'s policies). The outcome of the PMT, a list of public transportation projects infrastructure projects, becomes the pool of public transportation projects to be evaluated within *Journey to 2030*. The PMT performance measures are grouped into seven categories:

- "Utilization
- Mobility
- Cost-Effectiveness
- Air Quality
- Service Quality
- Economic and Land Use Impacts (not applied to general service enhancement projects)
- Environmental Justice"

Interestingly, the Air Quality category of performance measures contains specific criteria for the measure of CO₂, among other types of emissions. The CO₂ performance measures include:

- ***"Percent Reduction in Carbon Dioxide (CO₂) Emissions***
 - Projected percentage reduction in CO₂ emissions on weekdays, regionwide
- ***Capital Cost Per Unit Reduction in CO₂ Emissions***
 - Ratio between the capital cost of the project and the projected reduction in CO₂ emissions on weekdays, regionwide"

Other performance measures that do not mention CO₂, but would still result in

greenhouse gas mitigation include:

- ***“Reduction in Vehicle Miles Traveled***
 - Projected percentage reduction in weekday automobile vehicle miles traveled, regionwide
- ***Consistency With Local Plans That Promote Coordinated, Transit-Oriented Development and Support Sustainable Land Use Patterns In the Immediately Surrounding Area(s)***
 - Projects receiving a high rating are those for which:
 - At least 1/2 of the stations along the line are located in areas zoned for mixed-use development.
 - Projects receiving a medium rating are those for which:
 - At least 1/2 of the stations along the line are located in areas zoned for both high density residential and commercial development, or zoned for industrial development.”

3.2.2.2 City of Berkeley, California (55)

The City of Berkeley is in the process of creating its newest climate action plan in response to an overwhelming majority of voters (81%) approving Ballot Measure G, which read:

“Should the People of the City of Berkeley have a goal of 80% reduction in greenhouse gas emissions by 2050 and advise the Mayor to work with the community to develop a plan for Council adoption in 2007, which sets a ten year emissions reduction target and identifies actions by the City and residents to achieve both the ten year target and the ultimate goal of 80 percent emissions

reduction?”

The plan’s newly adopted greenhouse gas reduction target of 80% below 2000 levels by 2050 is ambitious, but the city feels that this goal is achievable. In calculating its baseline emissions for the years 2000 and 2005, the city estimates that emissions have already fallen by 8.9% during that five-year period. The plan includes many actions, which in this case is a synonym for objectives, to further reduce emissions over four categories: building energy use, sustainable transportation and land use, waste reduction and recycling, and community outreach and empowerment. Specific objectives for sustainable transportation and land use include:

- “Ensure that local land use decisions and policy are consistent with the goal of making alternative modes of transportation the mainstream
- Implement the City’s bicycle and pedestrian plans
- Make public transit more convenient and accessible
- Increase car sharing and ridesharing opportunities as an alternative to single occupancy driving
- Encourage more fuel-efficient vehicles, electric vehicles, and other alternatively fueled vehicles
- Enhance and expand education and outreach regarding alternative forms of transportation
- Expand the City’s alternative fuel vehicle program”

The mitigation objectives may be effective, but seem fairly consistent and standard with mitigation objectives of other cities and MPOs. Subsequently, the most interesting portion of Berkeley’s *Climate Action Plan* is actually its objectives for climate

change adaptation:

- “Conduct an assessment of the region’s vulnerability to the impacts of climate change
- Develop a strategic plan for climate change adaptation
- Implement the climate adaptation plan and continuously evaluate progress”

Through its adaptation objectives, the plan not only acknowledges that the climate is already changing but that the city’s understanding of how these changes will affect its infrastructure will require further assessment. Assessing the region’s vulnerabilities to the effects of climate change will allow for the city to prioritize areas of special concern, especially along the San Francisco Bay coast. The prioritization would eventually result in a strategic adaptation plan with an overarching goal of increasing the resilience of the region to change while continually evaluating progress as well as the continuing climate threat. Specific measures of the plan would consist of:

- “Increase public awareness about the impacts of climate change on our community
- Build strong partnerships across sectors (e.g., public health, environment, economic development, public works) so as to increase communication and reduce vulnerability
- Increase the adaptive capacity of the region’s infrastructure”

3.2.2.3 Portland Metro (53)

As discussed earlier, Metro, the designated MPO and regional government of the Portland, Oregon, area, is responsible for coordinating land use and transportation planning. Though there are separate plans for each (*2040 Growth Concept* and the *2035*

Regional Transportation Plan), “transportation planning and investment decisions and the region’s desired land use, economic and environmental outcomes are so interconnected that success of the 2040 Growth Concept hinges significantly on achieving the regional transportation goals presented in this [regional transportation] plan.” The sheer amount of goals and objectives presented in the transportation plan is staggering and extremely comprehensive relative to the plans of other MPOs. The goals and objectives of Metro’s transportation plan are in part a product of the metropolitan growth plan by emphasizing the movement of people and goods, not automobiles, through smart land use and transportation alternatives as well as lessening the region’s contribution towards climate change. Goals are presented with measurable objectives, or outcomes, and actions, or steps needed to accomplish goals. One of Metro’s goals, to “promote environmental stewardship,” has the most direct relevance to climate change, with objectives and potential actions such as:

- Objective: “**Clean Air** – Reduce transportation-related vehicle emissions to improve air quality so that as growth occurs, the view of the Cascades and the Coast Range from within the region are maintained and greenhouse gas emissions are reduced.
- Potential Actions:
 - *Implement investments that reduce transportation related vehicle emissions.*
 - *Encourage use of all low- or zero-emission modes of travel (e.g., transit, telecommuting, zero-emissions vehicles, carpooling, vanpooling, bicycles and walking).*

- *Work with the state to include and implement strategies for planning and managing air quality in the regional airshed in the State Implementation Plan (SIP) for the Portland-Vancouver air quality maintenance areas (AQMA) as required by the federal Clean Air Act Amendments.*
- *Ensure timely implementation and adequate funding for transportation control measures, as identified in the SIP.*
- *Monitor air quality, greenhouse gas emissions and air toxics within the regional airshed.*
- *Adopt targets to reduce greenhouse gas emissions to 10 percent below 1990 levels by 2020 and 75 percent below 1990 levels by 2050.*
- *Adopt offsetting land use actions and investments in transit and other modes that contribute to meeting greenhouse gas emissions targets.”*
- Objective: “**Energy and Land Consumption** - Reduce transportation-related energy and land consumption and the region’s dependence on unstable energy sources.
- Potential Actions:
 - *Implement investments that increase efficiency of the transportation network (e.g., reduce idling and corresponding fuel consumption) or supports efficient trip-making decisions in the region.*
 - *Promote and implement strategies to increase use of alternative energy vehicles and non-SOV travel modes.*
 - *Evaluate the effect of unstable energy sources and potential emerging energy technologies on long-term travel behavior in the region, including*

the development of new analytical tools needed to complete this evaluation, and whether RTP policies are adequate to adapt to changing energy conditions.”

Objectives of other goals, while not specifically concerned with climate change, are linked to Metro’s integrated planning vision and are ultimately supportive of its efforts to reduce greenhouse gas emissions. Some of these objectives include:

- **“Compact Urban Form and Design** - Use transportation investments to reinforce growth in, and multimodal access to 2040 Target Areas and ensure that development in 2040 Target Areas is consistent with and supports the transportation investments.”
- **“Parking Management** – Minimize the amount of land dedicated to vehicle parking.”
- **“Travel Choices** – Achieve Non-SOV modal targets for increased walking, bicycling, use of transit and shared ride and reduced reliance on the automobile and drive alone trips.”
- **“Vehicle Miles of Travel** - Reduce vehicle miles traveled per capita.”
- **“Demand Management** – Implement services, incentives, supportive infrastructure and increase awareness of travel options to reduce drive alone trips and protect reliability, consistent with Transportation System Management and Operations Concept.”

There are no goals or objectives that specifically seek to investigate the effects of global climate change on the transportation infrastructure of the Portland region.

However, within security and financial stewardship goals, one objective sounds as though

it could be a starting point for a potential risk management process that would be beneficial for climate change adaptation in the future:

- **“Terrorism, Natural Disasters and Hazardous Material Incidents** - Reduce vulnerability of the public, goods movement and critical transportation infrastructure to acts of terrorism, natural disasters, hazardous material spills or other hazardous incidents.”

General performance measures for the *2035 Regional Transportation Plan* such as modal split and LOS are commonly applied across all sections, but areas designated as mixed-use centers, known as areas of special concern, that will exceed vehicle performance measures can be evaluated under substitute performance measures that take into account the unique physical or environmental attributes of the area. These substitute performance measures are essentially context sensitive, ensuring that a congestion mitigation approach is not used in key areas identified in the *2040 Growth Concept* that may have specific land use visions. The substitute measures consist of parking ratios, non-single occupant vehicle (SOV) modal targets, and other measures at the intersection of transportation and land use.

Not all performance measures are in the transportation plan, however. Metro is awaiting input from Oregon to expand performance measures in line with state requirements (such as greenhouse gas reduction goals and objectives). Potential performance measures have already been identified during the federal component of the transportation plan and are grouped by the goal to which they support. Many indirectly, though not explicitly, relate to climate change mitigation efforts through land use, transportation alternatives, and VMT reduction, but several are designed to directly

measure greenhouse gas emissions. Under the environmental stewardship goal, two performance measures read:

- “Tons per year of carbon/green house gas emissions
- Calculate estimates of greenhouse gas emissions of potential transportation investments”

If expanded by the state, these measures could have significant impact on the evaluation process by allowing for alternative strategies or investment options to be evaluated for their unique contributions to climate change. With Oregon’s recent climate change legislation and subsequent greenhouse gas reduction targets, it would appear as though climate change performance measures will play an important role in future transportation plan updates.

3.2.2.4 Toronto’s Metrolinx (56)

In 2006, the Canadian province of Ontario established Toronto’s regional transportation planning authority, known to the public as Metrolinx. The most immediate and pressing assignment for the newly created planning authority was to produce Greater Toronto’s regional transportation plan. One of the first tasks for the development of the transportation plan was to initiate a working discussion on how the region would like to develop its transportation system. Metrolinx has begun the dialogue with its first white paper document, titled *Vision, Goals and Objectives*, which is available for public comment online.

Within the document, goals and supporting objectives are divided into vision categories. Climate change and greenhouse gas related goals and objectives are presented within the environmental vision category, as shown in Table 3.1. The majority

of these goals and objectives are concerned with smart growth and reductions in vehicle-related greenhouse gas emissions. One additional goal under an economic prosperity vision statement demonstrates the region's adaptive planning aspirations:

- “**Resilience:** By reducing our oil dependence, we will better withstand volatility in energy supply and prices, and have more flexibility to switch to new fuels and technologies. We will strive to anticipate the impacts of climate change on infrastructure.”

The draft white paper also includes a list of possible performance measures for each identified objective. Because climate change adaptation is a goal without any supporting objectives, possible performance measures relating to climate change are entirely in terms of mitigation. Examples of mitigation related performance measures include:

- “GHG emission levels per person-km and total emissions/year
- Total transportation-related energy use by type
- Total annual fuel and energy consumption
- Vehicle-km traveled (VKT) (total and per capita)
- Average number of weekday person trips by car
- Number of vehicles per household
- Average trip length from home to work
- Hectares of land dedicated to transportation infrastructure
- Availability of quantifiable measures and impacts on various choices to users including through trip-planning tools
- Percent of large employers (100+) with a *Transportation Demand Management*

plan”

Table 3.1: Goals and objectives from Toronto’s Metrolinx (56)

A THRIVING, HEALTHY AND PROTECTED ENVIRONMENT	
<i>We will plan, establish and maintain a transportation system that conserves resources and leaves a legacy of a healthy and clean environment for our children and grandchildren.</i>	
GOALS	OBJECTIVES
<p>I. A Smaller Carbon Footprint and Reduced Dependence on Non-Renewable Resources: Our transportation system will operate sustainably within the constraints of – and in balance with – ecosystems. Decisions about our transportation system will take into account its potential to impact air, land and water quality; human, plant and animal life; social, cultural and economic conditions; and the built environment.</p> <ul style="list-style-type: none"> • We will reduce GHGs – our carbon footprint – and other harmful emissions and discharges related to transportation to sustainable levels. • We will reduce our dependence on non-renewable resources like fossil fuels and man-made chemicals that accumulate in the environment. • We will use recyclable materials, for example, in construction materials and vehicles. 	<p>15. Decreased use of non-renewable resources</p> <p>16. Increased recycling rate of transportation-related construction materials and vehicles</p> <p>17. Reduced and stabilized transportation-related GHG emissions as per the provincial <i>Go Green: Ontario's Action Plan for Climate Change</i>: reductions of six per cent by 2014, 15 per cent by 2020, and 80 per cent by 2050</p> <p>18. Improved air quality</p> <p>19. Reduced car use</p> <p>20. Improved energy efficiency</p> <p>21. Reduced consumption of land for urban development</p>
<p>J. Reduced Land Consumption for Urban Development: The transportation system itself will use less space, help curb sprawl, and help promote and sustain more compact and efficient urban forms.</p>	<p>22. Reduced ecological impact to our agricultural and natural systems</p> <p>23. Increased awareness of how travel choices impact the environment</p>
<p>K. Adopt the Precautionary Principle and an Ecosystem Approach: In planning the transportation system of the <i>GTHA</i>, the precautionary principle will be applied to ensure that the environment is protected, conserved and wisely managed.</p>	

3.2.2.5 Puget Sound Regional Council (57)

The Puget Sound Regional Council (PSRC) is responsible for developing the long-range transportation plan as well as the growth strategy for the four-county Puget Sound metropolitan area. Much like Metro to the south, the PSRC’s main vision for the region is its growth concept plan, named *Vision 2040*, which combines planning efforts for transportation, land use, and economic development into one long range document. The regional transportation plan, named *Destination 2030*, is a stand-alone document, but

is ultimately intended to support the more comprehensive *Vision 2040* growth plan.

Subsequently, regional policy direction and goals for the transportation plan are actually presented in *Vision 2040*, while several broad-based transportation objectives are identified in *Destination 2030*.

The goals of *Vision 2040* are designed to support the vision for the region, which does explicitly mention climate change. Focus areas for goals are divided into six separate sections: environment, development patterns, housing, economy, transportation, and public services. For each section, an overarching goal is presented that guides additional goals and policies within that section. Several goals and policies are directly tied to climate change adaptation and greenhouse gas mitigation:

- Overarching *Environmental* Goal: “The region will care for the natural environment by protecting and restoring natural systems, conserving habitat, improving water quality, reducing greenhouse gas emissions and air pollutants, and addressing potential climate change impacts. The region acknowledges that the health of all residents is connected to the health of the environment. Planning at all levels should consider the impacts of land use, development patterns, and transportation on the ecosystem.”
 - Goal: “The region will safeguard the natural environment by meeting the needs of the present without compromising the ability of future generations to meet their own needs.”
 - Policy: “Maintain and, where possible, improve air and water quality, soils, and natural systems to ensure the health and well-being of people, animals, and plants. Reduce the impacts of

transportation on air and water quality, and climate change”

- Goal: “The overall quality of the region's air will be better than it is today.”
 - “Reduce levels for air toxics, fine particulates, and greenhouse gases.
 - Continue efforts to reduce pollutants from transportation activities, including through the use of cleaner fuels and vehicles and increasing alternatives to driving alone, as well as design and land use.”
- Goal: “The region will reduce its overall production of harmful elements that contribute to climate change.”
 - Address the central Puget Sound region's contribution to climate change by, at a minimum, committing to comply with state initiatives and directives regarding climate change and the reduction of greenhouse gases. Jurisdictions and agencies should work to include an analysis of climate change impacts when conducting an environmental review process under the State Environmental Policy Act.
 - Reduce the rate of energy use per capita, both in building use and in transportation activities.”
 - “Reduce greenhouse gases by expanding the use of conservation and alternative energy sources and by reducing vehicle miles traveled by increasing alternatives to driving alone.”

Vision 2040 also provides background information pertinent to its goals and policies. During the discussion of environmental stewardship, the PSRC briefly mentions what it calls “adaptive management.” This concept of adaptive management would appear to be the foundation for a risk management framework that could potentially focus its attention on climate change impacts. A definition for adaptive management is given as “a structured, iterative process of decision-making when there is incomplete knowledge or a level of uncertainty. It relies on implementing actions to provide knowledge, as well as learning from outcomes, in order to adapt future actions to reduce uncertainty over time.”

To further reinforce the relevance of its goals and policies concerning climate change, *Vision 2040* presents other initiatives within the state of Washington that seek to address greenhouse gas emissions. Local actors, including King County and Seattle, have established their own climate action plans, while Washington legislative and executive initiatives have begun popping up as well. Both the legislature and Governor have created their own emissions reduction goals that are identical to each other:

- 1990 levels by 2020
- 25% below 1990 levels by 2035
- 50% below 1990 levels by 2050

The PSRC also recognizes the need to combine all the recent climate change planning efforts to facilitate a more coordinated approach to reduce greenhouse gas emissions. One final goal within the environmental portion of *Vision 2040* is to create a regional and local climate change action plan that will be developed by the PSRC (and all members), state organizations, and the Puget Sound Clean Air Agency. The goal

statement says the action plan should:

- “Address climate change in accordance with the Governor's 2007 Climate Change initiative and state legislation on greenhouse gas emissions reduction
- Reduce greenhouse gas emissions
- Take specific mitigation steps to address climate change impacts”
- “Address establishing a regional climate change benchmark program”

3.2.3 Analysis

3.2.3.1 Atlanta Regional Commission (58)

The Atlanta Regional Commission (ARC) recently conducted an analysis of current and future greenhouse gas emissions within the Atlanta metropolitan region using Mobile6¹² as well as the regional travel demand model. Mobile6 was used to obtain vehicle emissions factors while the travel demand model was used to calculate VMT throughout the metropolitan area. To calculate the emissions factors, the ARC utilized vehicle fleet characteristics that were employed for the most recent conformity analysis. Baseline emissions factors for 1990 were created under the assumption that metropolitan fuel economy has stagnated around 17 mpg due to high growth in minivans and sport utility vehicles, as shown in Figure 3.3. Emissions factors estimated over the planning horizon (2030) assumed a more efficient vehicle fleet due to the *Energy Independence and Security Act of 2007*. Figure 3.4 shows the dramatic effects of the EISA on metropolitan Atlanta's CO₂ emissions compared between local plans and the regional transportation plan, *Envision6*.

¹² EPA's pollutant dispersion model

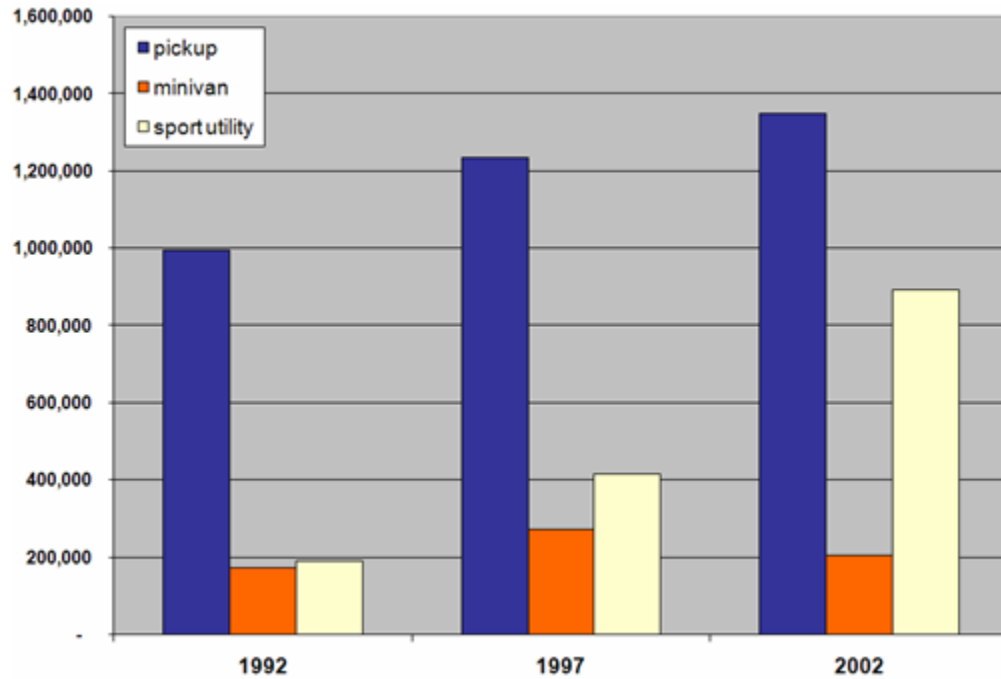


Figure 3.3: Vehicle fleet characteristics within the metropolitan Atlanta area (58)

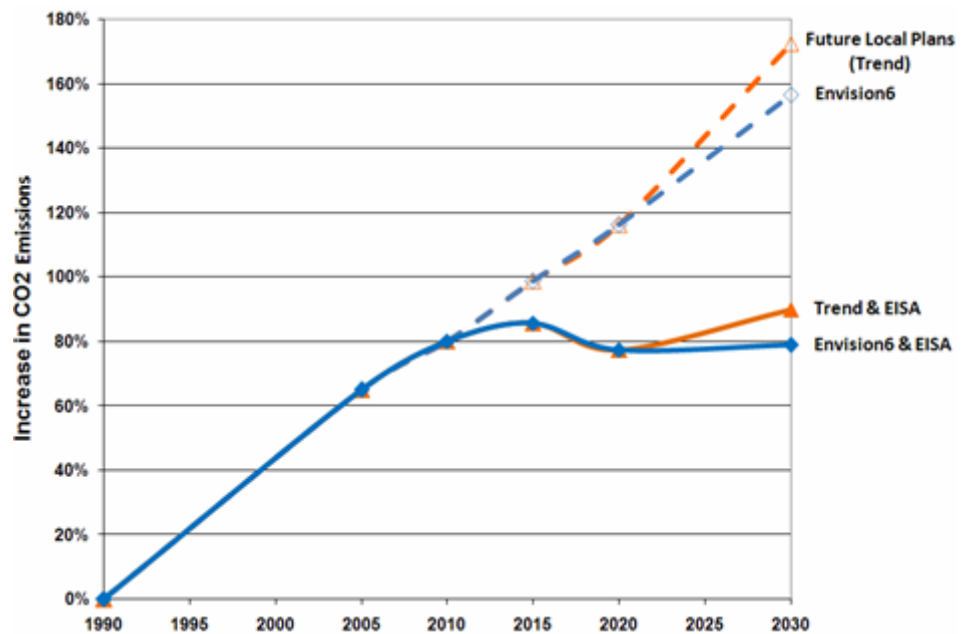


Figure 3.4: Impacts of the EISA on CO₂ emissions within the metropolitan Atlanta area (58)

The other half of the CO₂ equation, VMT, was estimated using the regional travel demand models, but the baseline VMT data for 1990 was provided by the Georgia Department of Transportation. The regional travel demand model took into account a variety of land use scenarios to obtain future ranges of both VMT and CO₂ emissions. Figure 3.5 demonstrates the differences between the adopted *Envision6* regional transportation plan, the Transit Planning Board's *Concept3* plan, and the *Concept3* plan coupled with transit-focused land use. At best, the transit-focused *Concept3* plan is expected to result in a 7% decrease in surface transportation CO₂ emissions, or a 58% increase from 1990. These results highlight the difficulty of reaching significant reductions in transportation related CO₂ emissions, especially in an area, such as the Atlanta region, that has seen a tremendous population growth from 1990 to 2005.

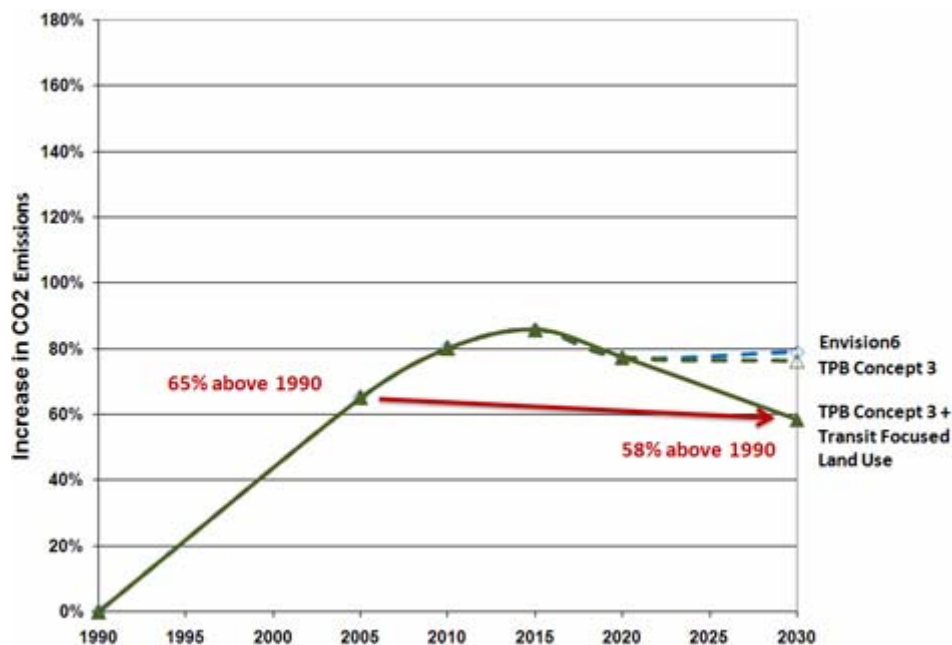


Figure 3.5: CO₂ emissions resulting from EISA and regional transportation and land use plans (58)

3.2.3.2 City of Brisbane, Australia (59)

Within the past few years, the Brisbane City Council (BCC) created the Climate Change and Energy Taskforce in order to help the city prepare for climate change. The taskforce was ultimately responsible for developing non-binding recommendations for the BCC, which are presented in its report, the *Climate Change and Energy Taskforce Final Report: A Call for Action*. Recommendations focus not only on mitigation of greenhouse gases, but also on adapting to the effects of climate change.

An assessment of exposure to the effects of climate change was conducted through a working partnership between the Queensland government and the Commonwealth Scientific and Industrial Research Organisation¹³ (CSIRO). The exposure assessment, shown in Table 3.2, was created specifically for Queensland, the state in which Brisbane resides, but nonetheless provides a general idea of what to expect from climate change in the Brisbane area. While the exposure assessment was not specifically performed by or prepared for the BCC, the taskforce's use of such available information demonstrates the reality that current exposure analysis techniques cannot be narrowed down to the metropolitan level. Until the science is more precise, the best source of information for climate exposure may very well come from higher levels of government or regional climate studies.

Brisbane's unique geography at the confluence of the Brisbane River and Moreton Bay, coupled with high-expectancy of sea level rise and increasing storm surge, will make it an ideal location for severe flooding if climate change effects are realized. The BCC has recognized this threat and examined the topography of the city to determine where flooding can be expected in the future. The flood maps are available in the *Final*

¹³ CSIRO is a national scientific research organization in Australia

Report, but are too large and detailed for inclusion in this document, and show that most the threat remains at coastal areas while more upstream locations, such as downtown, are less susceptible to flooding. Not surprisingly, one of the recommendations of the taskforce is to begin planning for adaptation of critical infrastructure to the effects of a changing climate.

Table 3.2: CSIRO's projections of Queensland's future climate (59)

Level of Confidence	CSIRO Climate Change Projection for Queensland
Very high - >90% chance	<ul style="list-style-type: none"> • Higher temperatures and changes in extreme temperatures • Global sea level rise • Declining soil moisture
High - 90% chance	<ul style="list-style-type: none"> • Decreasing average rainfall • Increasing potential evaporation • Increasing storm surge heights/risk along the East coast of Qld • Increasing tropical cyclone intensity • Increasing temperatures at the regional scale, including extremes
Medium - 66% chance	<ul style="list-style-type: none"> • Increased risk of bushfire • Increased incidence of extreme rainfall
Moderate >50% chance	<ul style="list-style-type: none"> • Decline in overall amount of rainfall and seasonality of that change • Changes in average stream flow • Increased drought
Low	<ul style="list-style-type: none"> • Abrupt changes, such as melting of polar ice sheets and changes in global ocean currents.

3.2.3.3 City of London, United Kingdom (60)

The London Climate Change Partnership (LCCP), headed by the Greater London Authority and comprised of a wide variety of stakeholders, is an organization entirely dedicated to adapting London to future climate change. The LCCP commissioned a document in 2005, *Climate Change and London's Transport Systems*, which qualitatively assessed climate change effects through four case studies around the London area. The case studies are:

1. Tidal and river flood risk and London Thames Gateway: London and the Thames Estuary are protected by the Thames Tidal Defense system, which will protect against large and rare flooding events. Components of the transportation infrastructure around Thames Gateway are designed to withstand floodwaters. Flood defense in the area is expected to diminish as climate change brings more frequent and intense storms, presenting a risk for the transportation infrastructure of the developing area. Because the infrastructure is still being developed (at the time of publication), design adaptations may still be incorporated, though cost estimates are not known. Flood risk assessments are underway for the area. The report recommends flood-proofing infrastructure when needed or relocating it to areas of less risk.
2. Infrastructure damage and station close caused by local flooding: Flooding Underground stations is fairly common and costs millions of pounds in infrastructure damage and passenger delay. More frequent and intense storms from climate change would exacerbate the issue, especially during the summer months. Flood-prone areas are being mapped to help manage occurrences and risk reduction techniques are being developed with the results of London Underground's Quantified Risk Assessment model. The LCCP report recommends that measures and actions to adapt the stations to increased risk, adaptation planning should be conducted with the help of all relevant agencies, proper data collection to fully quantify potential risk, and research on groundwater impacts from climate change.
3. Infrastructure damage in hot weather: Hot summers are causing speed restrictions

on railways during especially warm days, causing much economic burden for the London region. Climate change is expected to cause an increase in the number of exceptionally hot summer days, which could produce rail issues such as “carriageway rutting, embankment subsidence, deterioration of concrete, problems with expansion joints, increase in dust levels and reduction in skid resistance.” Roadway deterioration is expected as well. Network Rail is currently researching the effects of climate change on rail operations, infrastructure, and safety. The LCCP report further recommends additional work to assess true costs of rail delay, more research to understand climate impacts, and a review of rail and roadway asset conditions.

4. Passenger comfort on the Underground: Temperatures in stations can reach 40°C and may rise even further due to climate change. Cooling the Underground is a topic of concern for the Mayor and Transport for London (TfL), and there are several projects that aim to address this issue. The LCCP report further recommends additional research to establish passenger comfort thresholds that might cause a change in transportation mode.

The qualitative analysis of the LCCP report is by no means definitive, but it represents a step in the right direction for adaptation planning in the London area. At the very least, the case study analysis serves as a springboard for recommendations of future adaptive actions and strategies.

3.2.3.4 New York Metropolitan Transportation Council (50, 61)

As mentioned earlier, the *New York State Energy Plan*, helped guide the vision, goals and objectives of the NYMTC’s *2005-2030 Regional Transportation Plan*. The

energy plan identifies specific greenhouse gas reduction goals as well as suggested strategies for addressing CO₂ through transportation measures. In response, the NYMTC has developed a document, known as the *Consistency Assessment*, which specifically assesses uniformity between state greenhouse gas and energy efficiency recommendations with the metropolitan long-range transportation plan and TIP. Of particular interest in the *Consistency Assessment* are the analysis procedures undertaken by the NYMTC for the purpose of developing its long-range plan.

For its general travel forecast analysis, the NYMTC uses an activity based travel demand model known as the *New York Best Practice Model* (NYBPM). The NYBPM covers a large area of 28 separate counties comprised of 3,500 traffic analysis zones (TAZ). Geographic information system (GIS) is used to model the region's extensive highway and transit assets. Highways alone total approximately 53,000 segments, and every transit mode, even including ferries, are represented in the model. The model can analyze up to eight different trip purposes over four time periods. Example input data needed includes:

- “Household, population and employment data at the BPM zonal level and future year forecasts extended to 2030
- 2000 Census data
- Updated 24-hour traffic counts at 2,300 screenline locations
- Updated transit ridership”

The baseline year for analysis was 2002. Subsequently, socioeconomic data, such as employment and population, was reflective of post 9/11 levels. In forecasting the region's greenhouse gas emissions and transportation-related energy use, the NYMTC

decided to run the NYBPM for the years 2010, 2020, and 2030. An estimate of emissions and energy consumption for the baseline year of 2002 was required in order to compare the forecast results. The analyses for the target years were focused on two general scenarios, build or no build. The build scenario assumed that all projects recognized from both the *2005-2030 Regional Transportation Plan* and TIP are constructed, while the no build scenario assumes that no projects were constructed after the baseline year. The NYMTC utilized existing model output, namely VMT and speed, in order to calculate energy consumption, and then used the energy consumption to calculate greenhouse gas emissions.

Results from the process are presented in Tables 3.3 and 3.4. Table 3.3 shows the direct energy (in 1000s of British Thermal Units, or BTU) and greenhouse gas (in tons) results from the build and no build scenarios, and Table 3.4 shows the indirect energy results for the same scenarios and time periods. Direct energy is a reference to transportation operations, while indirect energy is the result of construction operations. Consequently, indirect energy for the build scenario is actually higher due to the construction of regional transportation projects. Overall, energy consumption and greenhouse gas emissions (including both direct and indirect energy) are lower for the build scenario. The *Consistency Assessment* concludes that its planning documents are aligned with the *New York State Energy Plan*.

Table 3.3: Direct energy results of *Consistency Assessment* analysis (61)

		Direct Energy			
		Build	No- Build		
Year	VMT	Direct Energy BTU(1000s)	VMT	Direct Energy BTU (1000s)	
2002			182,193,403	1,256,105,041	
2007	185,373,685	1,298,864,250	189,173,923	1,325,877,117	
2010	187,366,944	1,324,443,254	190,090,562	1,343,362,754	
2020	196,345,940	1,383,430,720	199,839,791	1,396,856,710	
2025	201,859,483	1,404,369,845	206,524,746	1,438,170,577	
2028	203,923,270	1,421,486,947	207,303,936	1,445,328,498	
2030	204,924,615	1,425,608,563	208,994,976	1,457,928,830	

		Direct Greenhouse Gas Emissions			
		Build		No- Build	
Year	VMT	Direct Greenhouse Energy (tons)	VMT	Direct Greenhouse Energy (tons)	
2002			182,193,403	97,408	
2007	185,373,685	100,750	189,173,923	102,847	
2010	187,366,944	102,748	190,090,562	104,214	
2020	196,345,940	107,379	199,839,791	108,415	
2025	201,859,483	109,035	206,524,746	111,863	
2028	203,923,270	110,406	207,303,936	112,258	
2030	204,924,615	110,736	208,994,976	113,256	

Table 3.4: Indirect energy results of *Consistency Assessment* analysis (61)

		In-Direct Energy			
		Build	No- Build		
Year	VMT	In-direct Energy BTU (1000s)	VMT	In-Direct Energy BTU (1000s)	
2002			182,193,403	15,828,837	
2007	185,373,686	15,891,423	189,173,923	15,821,643	
2010	187,366,944	15,968,524	190,090,562	15,867,295	
2020	196,345,940	16,083,466	199,839,791	16,004,664	
2025	201,859,483	16,185,558	206,524,746	16,035,370	
2028	203,923,270	16,198,679	207,303,936	16,053,927	
2030	204,924,615	16,165,156	208,994,976	16,077,066	

		In-Direct Greenhouse Gas Emissions			
Build			No- Build		
Year	VMT	In-Direct Greenhouse Gas (T)	VMT	In-Direct Greenhouse Gas (tons)	
2002			182,193,403	1,275	
2007	185,373,685	1,280	189,173,923	1,275	
2010	187,366,944	1,287	190,090,562	1,278	
2020	196,345,940	1,296	199,839,791	1,289	
2025	201,859,483	1,304	206,524,746	1,292	
2028	203,923,270	1,305	207,303,936	1,293	
2030	204,924,615	1302	208,994,976	1,295	

3.2.3.5 San Joaquin Council of Governments (62, 63)

The San Joaquin Council of Governments (SJCOG) serves as the regional MPO for San Joaquin County, California, and its seven cities. The county's largest urban area is the City of Stockton, home to approximately 300,000 people and growing rapidly. SJCOG is responsible for the county's regional transportation plan, which must be

accompanied by an environmental impact report (EIR) as required by the *California Environmental Quality Act* (CEQA). According to CEQA, climate change must be considered during the EIR analysis process to determine the plan's overall contribution of greenhouse gas emissions. This requirement received further emphasis with the passing of California Assembly Bill 32, known as the *Global Warming Solutions Act of 2006*, because of new greenhouse gas targets requiring emissions to equal 1990 levels by 2020, which constitutes a 25% reduction under projected increases. In the draft EIR document for its *2007 Regional Transportation Plan*, the SJCOG analyzed three alternatives:

- No-Project Alternative
- Transit/Alternative Modes Emphasis Alternative
- Highway Emphasis Alternative

The air quality analysis for the three alternatives was conducted using projected VMT and vehicle-hours traveled (VHT) for existing (2006) and future (2030) conditions. As mandated by CEQA, the air quality analysis must include projected greenhouse gas emissions, but the SJCOG initially did not establish a methodology to estimate baseline greenhouse gases. The SJCOG said that a proper analysis was not done because “the agencies with jurisdiction over air quality regulation and GHG emissions such as the ARB¹⁴ and the SJVAPCD¹⁵ have not established regulations, guidance, methodologies, significance thresholds, standards, or analysis protocols for the assessment of greenhouse gas emissions and climate change.” Subsequently, a very qualitative assessment of projected greenhouse gas emissions was given. The SJCOG concluded that it was “probable” that emissions would be reduced as a result of the build alternative, compared

¹⁴ California Air Resources Board

¹⁵ San Joaquin Valley Air Pollution Control District

to the no-build alternative, due to increased funding of public transportation and more efficient traffic operations. The SJCOG then asserted that the county's global contribution to climate change (0.03% of global emissions) is not of sufficient magnitude to affect global warming when taken in isolation, even though the EIR then states that the cumulative effects of climate change may distress California and San Joaquin County. As a result, the significance of greenhouse gas impacts was designated as undeterminable.

During the comment period, however, the need for an emissions analysis was made clear by an official letter from the California Attorney General. The letter stresses that the qualitative analysis presented in the draft EIR was not sufficient in addressing the regional transportation plan's emissions contributions. Specifically, the letter states that a proper analysis is required to address robust growth of VMT (from 17.63 million to 30.86 million VMT/day) over the planning period, and that the MPO could not claim that emissions would probably be less due to the build alternative when, in fact, new road capacity must be implemented to handle the expected growth of 400,000 residents. In addition, the letter states that it is "erroneous" for the SJCOG to declare greenhouse gas emissions insignificant in the absence of state guidelines or thresholds, and "neither CEQA, nor the regulations, authorize reliance on the lack of an agency-adopted standard as the basis for determining that a project's potential cumulative impact is not significant."

The SJCOG prepared a lengthy point-by-point response to the letter from the California Attorney General that was inserted into the final EIR. The SJCOG also fulfilled its requirement and quantified greenhouse gas emissions for the baseline year of

2006 and the planning horizon of 2030, as shown in Table 3.5. For the planning horizon, four alternatives were considered: no build alternative, regional transportation plan preferred alternative, highway alternative, and transit alternative. Greenhouse gases were estimated by using VMT projections over the planning period, much in the same way as done by the NYMTC. As demonstrated in Table 3.5, emissions for all build scenarios are lower than the no-build scenario, yet still much higher than 2006 levels.

Table 3.5: Projected greenhouse gas emissions summary (63)

Emission Summary (Tons/Day)					
Pollutant	2006 Existing	2030 No Build	2030 RTP	2030 Highway	2030 Transit
CO	84.7	27.4	23.6	23.4	23.4
ROG	4.3	1.1	0.9	0.8	0.9
NO _x	30.0	5.3	5.1	5.1	5.0
PM-10	0.9	1.2	1.4	1.2	1.2
CO ₂	8,723.1	15,407.4	13,638.8	13,506.3	13,418.1
Emission Summary (Tons/Year)					
Pollutant	2006 Existing	2030 No Build	2030 RTP	2030 Highway	2030 Transit
CO	30,920	10,009	8,618	8,534	8,529
ROG	1,552	390	310	307	315
NO _x	10,935	1,939	1,875	1,857	1,832
PM-10	340	453	497	443	437
CO ₂	3,183,925	5,623,715	4,978,144	4,929,785	4,897,595

3.2.4 Strategies

3.2.4.1 City of London, United Kingdom (64)

Transport for London, part of the Greater London Authority, was created in 2000 to directly manage and plan for London's transportation system, including public, rail, and surface transportation. TfL's most recent transportation plan was released in 2006,

and is titled *Transport 2025: Transport Vision for a Growing World City*. The plan is particularly focused on addressing and tackling the issue of climate change both in terms of mitigation of greenhouse gases and the need to adapt to the effects on London's infrastructure. However, only mitigation is given serious consideration by performance measures, the analysis process, and strategy formation.

Transport 2025 initially conducts an analysis of one scenario, known as the Reference Scenario, which represents all projects included in the 2010 investment program. The Reference Scenario was analyzed using a typical four-step travel demand model and a public transportation assignment model. The Reference Scenario was modeled by itself in order to compare the results to the plan's vision and objectives, of which climate change was a major concern. The results of the Reference Scenario demonstrated that 2010 investment program alone would only achieve a reduction of 6% below 1990 emissions, which was not enough to meet the Mayor's greenhouse gas reductions target of 30% below 1990 levels by 2025. Six general strategies were identified to rise above the limitations discovered in the Reference Scenario, and all have a relationship with greenhouse gas emissions:

- “Renewing the existing system:” Renewal of the London Underground system will provide new capacity through delay reduction, which would reduce CO₂ emissions from trips otherwise taken by automobile. Renewal of buses will lower CO₂ emissions through low carbon technology, resulting in 40% reductions in emissions per vehicle.
- “Ensuring the existing system is efficient and safe:” CO₂ emissions should be reduced through efficiency improvements in the London Underground

- “Reducing the need to travel:” Reduced CO₂ emissions from TDM strategies, land use planning, and restricting automobile parking in transit accessible areas
- “Influencing travel behavior:” Reduced CO₂ emissions from strategies that lower automobile travel and increase the demand of alternative modes of transportation, such as discounted transit fares and managing the parking supply
- “Reducing congestion and emissions:” Reduced CO₂ emissions shifting the modal split in favor of public transportation by more efficiently using and managing limited road space (e.g. road pricing and transit priority)
- “Providing new capacity”

Given the urban nature of London, TfL recognized that the most suitable route for transportation system expansion would be the public transportation network, which is why the agency created three additional capital expansion scenarios that were analyzed and compared to the Reference Scenario. Each additional scenario includes the projects and strategies of the previous scenarios. The modeled scenarios are:

1. Reference Scenario
2. Full PPP¹⁶ Scenario (includes Reference Scenario): Main component is the PPP that will increase the efficiency of the London Underground
3. Crossrail Scenario (includes Reference and Full PPP scenarios): Main component is to provide east-west rail linkage between central London and the Isle of Dogs
4. T2025 Programme [sic] Scenario (includes all previous three scenarios): Main component is expansion of rail and light rail, as well as upgraded rail in the south east to help promote job growth

¹⁶ Public Private Partnership

The results of the analysis show that the T2025 Scenario comes the closest to meeting the Mayor's climate reduction target of 30% below 1990 levels by 2025. The T2025 Scenario is estimated to reduce greenhouse gas emissions by approximately 22% below 1990 levels, which equates to 17% below the Reference Scenario. This scenario is also expected to reduce travel delay below 1990 levels and shift mode share to alternative modes of transportation, both of which will help reduce CO₂ for the city.

3.2.4.2 Toronto's Metrolinx (65)

In its second white paper, *Preliminary Directions and Concepts*, Greater Toronto's Metrolinx has conducted its initial alternatives analysis to encourage public comment and serve as the foundation of subsequent analyses within the final regional transportation plan. In total, four alternatives were used in the travel simulation analysis, including one business-as-usual alternative and three additional test concepts that were defined to reflect the region's vision, goals and objectives, gaps and deficiencies of the transportation system, and other municipal and provincial transportation plans and policies. The three test concepts are:

- Linear (Concept A): Based on the *MoveOntario 2020* plan
- Radial (Concept B): Based on the linear concept but further expansion is focused in a radial pattern from Union Station in downtown Toronto
- Web (Concept C): Based on the radial concept but further expansion is focused on east-west corridors and adds rapid transit to areas identified by Toronto's *Official Plan*.

After the analysis was concluded and the results from all alternatives were tabulated, Metrolinx had to identify which alternative provided the best opportunity to

help meet Ontario's greenhouse gas reduction target of 20% below 1990 emissions by 2020. Ontario's target also defines from where the emissions reductions will take place, with passenger travel (personal automobile and transit) expected to contribute 13% of the total reduction. Based on the projected greenhouse gas emissions from Metrolinx's analysis of the business-as-usual alternative, passenger travel emissions would have to be reduced by approximately 6 Mt in order to meet the goal, as shown in Figure 3.6. The previous analysis of Metrolinx's three test concepts demonstrated that Concept C, the web concept, presented the best change of yielding the required reduction.

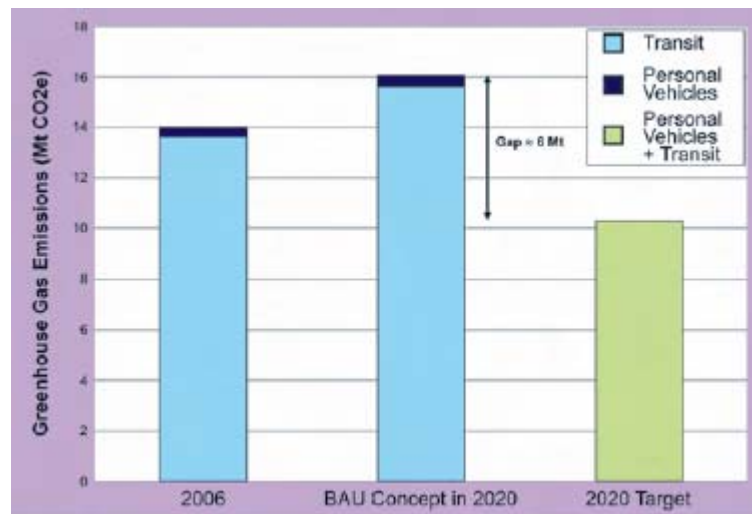


Figure 3.6: Greater Toronto passenger travel greenhouse gas emissions (65)

Three general strategies in line with Concept C were identified to meet the reduction target of roughly 6 Mt. Figure 3.7 shows each strategy with its expected contribution to the 2020 target. Cleaner electricity is estimated to reduce emissions by 0.3 Mt and only works under the assumption that coal-based power plants will be replaced with renewable and nuclear energy to power the metropolitan area's electricity-based transit systems. Improved vehicle technology is estimated to reduce emissions by

2.9 Mt and would ultimately be the responsibility of Ontario. The last general strategy of transit investment, concentrated land use, and aggressive TDM is estimated to reduce emissions by 2.6 Mt and represents the only area where metropolitan planners and policy makers can contribute to the reduction target without partnering with provincial or federal government. From such a general strategy, Metrolinx has identified more specific strategies that could contribute to greenhouse gas reductions with existing technology:

- “Extensive transit/transportation improvements derived from Test Concept C that could be practically implemented as of 2020, representing new *rapid transit* services brought to the doorsteps of millions more people, with expanded regional connectivity;
- An improved experience for all transit users to ensure that new and existing services are well-used;
- Land use measures building on the *Growth Plan* that encourage a greater mix of uses and higher densities to reduce the distances that people need to travel;
- Land use measures that ensure the design of our communities makes it safe, fast and convenient for people to walk, cycle and take transit;
- An aggressive package of *TDM* measures to reduce vehicle-kilometers-traveled (VKT), reduce traffic peaks, increase vehicle occupancy, encourage non-auto modes of transportation, and reduce non-essential travel. This includes extensive marketing and incentives regarding transit and carpooling, as well as some form of road pricing across the region to ensure a level playing field and encourage users to make sustainable transportation choices; and
- Measures to encourage *active transportation*.”

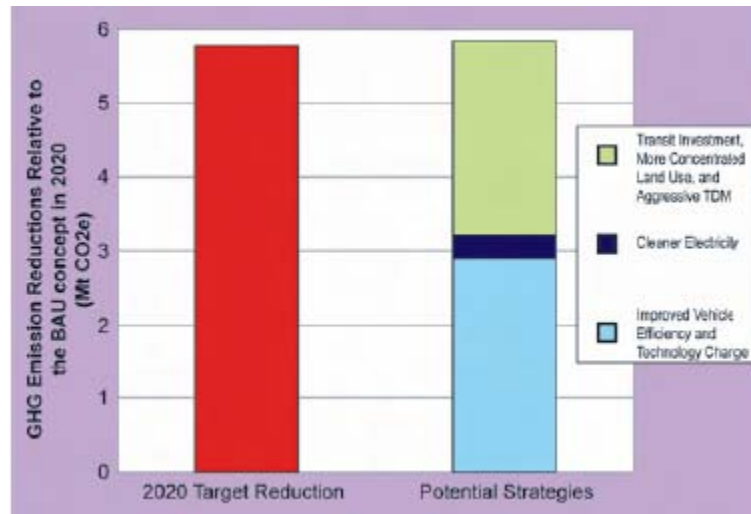


Figure 3.7: Potential strategies for meeting the passenger travel GHG emissions targets (65)

3.2.4.3 New York City, New York (66)

The Bloomberg administration has outlined its sustainable vision for New York City, *PlaNYC*, which includes climate change strategies among many other sustainability topics. The plan hopes to achieve a reduction in greenhouse gas emissions of 30% below 2005 levels by 2030. Sprawl avoidance and sustainable transportation strategies account for an estimated reduction of 21.7 million metric tons, or approximately 44% of this reduction goal. Mitigation strategies in support of these goals include:

- “Build and expand transit infrastructure
- Improve transit service on existing infrastructure
- Promote other sustainable modes
- Improve traffic flow by reducing congestion
- Achieve a state of good repair on our roads and transit system”
- “Reduce road vehicle emissions
- Reduce other transportation emissions”

PlaNYC also includes a specific climate change adaptation component, which is concerned with protecting all types of critical infrastructure, transportation included, from the potentially hazardous effects of a changing climate. The plan pays particular attention to potential sea-level rise and flooding due to the low-lying, coastal topography of New York City. A case study of prior New York City disaster planning efforts demonstrates the strong need for climate change adaptation plans and policies. Figure 3.8 shows the results of the case study's flood analysis of New York City. The analysis was used to define flood evacuation zones in terms of three levels of hurricane intensity: category 1 or higher, category 2 or higher, and category 3 or 4. As would be expected, immediate coastal areas are particularly vulnerable to the lowest hurricane intensity, especially Staten Island, but a significant portion of Brooklyn and many other areas of the city are quite susceptible to category 2, 3 and 4 hurricanes. A strong hurricane in this area would have devastating consequences. For example, a category 3 hurricane would not only require the evacuation of 3 million residents but it is estimated that it "could create a surge of up to 16 feet at La Guardia Airport, 21 feet at the Lincoln Tunnel entrance, 24 feet at the Battery Tunnel, and 25 feet at John F. Kennedy International Airport." Clearly more frequent and intense storms associated with climate change pose a serious threat to transportation infrastructure in New York City.

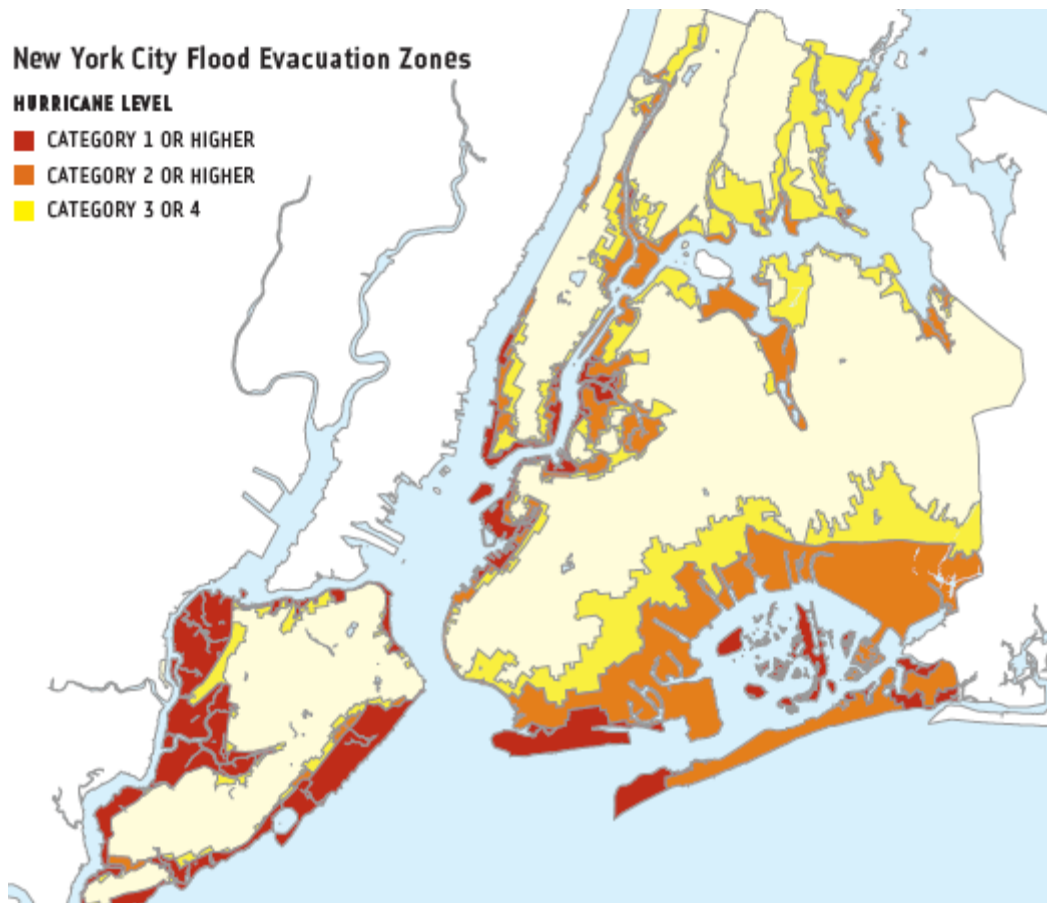


Figure 3.8: New York City flood evacuation zones by hurricane intensity (66)

The city is taking this threat very seriously, which is why *PlaNYC* includes three general adaptation strategies:

- “Create an intergovernmental task force to protect our vital infrastructure
- Work with vulnerable neighborhoods to develop site-specific strategies
- Launch a city-wide strategic planning process for climate change adaptation”

The plan emphasizes careful evaluation of climate risks and infrastructure vulnerabilities, which is why the city will create a Climate Change Advisory Board with a purpose of producing an adaptive planning framework for the Office of Long-Term Planning and Sustainability. The framework will be centered on a risk management and cost-benefit analysis through the use of explicit performance measures. Because this is a

first-of-its-kind initiative for any major U.S. city, a scoping study designed to identify an adequate planning methodology is required. In addition, the city plans to revise its 100-year flood maps with FEMA, a process last undergone in 1983.

3.2.4.4 New York Metropolitan Council of Governments (61, 67)

The analysis of energy consumption and greenhouse gas emissions within the NYMTC's *Consistency Assessment* document has demonstrated that the NYMTC's strategies and projects should comply with the *New York State Energy Plan* over the next several decades. Examples of these strategies already implemented by the NYMTC include:

- “Regional Commuter Choice Programs (RCCP)
 - Commuter Benefits
 - Transportation Demand Management Programs
 - Enhanced Ozone Action Days
 - Best Workplaces for Commuters
 - Unified Brand Development, Promotion and Outreach Campaign for RCCP
- Regional Signal Timing Program
- Regional Clean Fuels Program
 - Clean Cities and Clean Communities Programs
 - Clean Technologies Group
 - Fleet Coordination”

Examples of projects that have yet to be implemented but are under evaluation include:

- “Regional Idling Reduction Programs
 - Truck Stop Electrification Programs
- Land Use Strategies
- Regional Parking Pricing”

These sample strategies are currently only concerned with mitigation of greenhouse gas emissions as a result of the *New York State Energy Plan*’s policy objectives. There is, however, one policy objective of the energy plan that mentions “supporting the continued safe, secure, and reliable operation of the State’s energy and transportation system infrastructures,” but from the information in the energy plan’s update report it appears as though this objective is only applying to energy infrastructure at the moment. If this objective were tied to climate change in a future update, it may serve as a potential springboard for risk management adaptation strategies at the NYMTC. But despite the lack of adaptation strategies, the *Consistency Assessment* report states that all of the NYMTC’s nine strategic topics¹⁷ provide “opportunities to consider further strategies for reducing energy consumption (which will result in further reductions of greenhouse gas emissions) as important considerations in the development of the MPO’s planning products, policies, and programs, particularly as future TIPs and Plans are developed.”

3.2.4.5 San Joaquin Council of Governments (63)

In its defense, the SJCOG’s response to the California Attorney General’s claim that the agency had not adequately assessed greenhouse gas emissions resulting from its

¹⁷ Infrastructure, mobility, land use and transportation, safety, airport access, freight transportation, quality of life, regional planning, and decision making and financing the future

2007 Regional Transportation Plan is fairly comprehensive. Not only did the MPO update its greenhouse gas analysis process to produce quantifiable emissions projections, but the agency also highlighted many of its strategic efforts to comply with state mandated reduction targets. The final EIR for the SJCOG's transportation plan is quick to highlight that 29% of the plan's total allocated project funds are dedicated to efforts it believes will reduce greenhouse gas emissions over planning period, which includes:

- "Expansion of bus transit (\$2.2 billion)"
- Expansion of "rail use (\$670 million)"
- Expansion of "bicycle/pedestrian facilities (\$40 million)"
- Expansion of "rideshare programs (\$25 million)"
- Expansion of "transportation control measures (\$70 million)"

More specifically, the SJCOG points to several specific alternative programs that it thinks will reduce emissions, such as:

- "Congestion Management Plan"
- "HOV/Ramp Metering"
- "Measure K Smart Growth Element:" Measure K is a ½ cent sales tax for San Joaquin County transportation projects, but a portion of these funds are dedicated to smart growth planning and projects for local jurisdictions. The SJCOG identifies smart growth as a tool to lower VMT and greenhouse gas emissions, citing the same conclusion from the *Climate Action Program at Caltrans*.
- Ridesharing

- 511 Program: Providing citizens with traffic and transit activity in the county can be considered an information technology mitigation technique, according to the *California Climate Action Team Report*.
- “Park and Ride Lot Master Plan”
- “San Joaquin Valley Regional Blueprint:” The Blueprint planning process was established as a voluntary competitive grant program by the California Business, Transportation & Housing Agency to assist MPOs within the state in creating a regional growth strategy by using comprehensive scenario planning techniques. The SJCOG is working with partners in the eight-county San Joaquin Valley region to develop a Blueprint strategy that will create a regional transportation, land use, and economic development vision.
- Intelligent Transportation Systems

The SJCOG expects that greenhouse gases will see reduction beyond what has been highlighted in the final EIR once evaluation and implementation strategies have been identified through state agencies such as the ARB and adopted at the regional level.

3.2.5 Evaluation Process

3.2.5.1 Boston Region Metropolitan Planning Organization (43)

The BMPO is one of the few MPOs in the country with policies that specifically state that greenhouse gases will be considered during the project selection process, as shown earlier in the Vision section. The agency initially creates two pools of expansion projects that are considered for inclusion in the recommended plan, the Universe of Highway Projects and the Universe of Transit Projects. Because the recommended plan

must be financially constrained, an evaluation process must discriminate against projects that do not reflect the policies of the BMPO. In addition to such an evaluation process, projects are considered for the recommended plan by using travel demand modeling results as well as “information produced by feasibility studies, project-specific studies, project-specific modeling work, environmental impact reports, input from local officials, and information produced in the MPO’s Mobility Management System.”

Each Universe of Projects, highway and transit, has its own evaluation criteria. For highway projects, the evaluation process is a ranking system that assigns values, ranging from -3 to 3, for certain measures and gives specific Mobility Management System (MMS) output data for others (e.g. delay, speed, volume to capacity ratios). A negative rating is meant to denote negative impacts. CO₂ emissions are clumped with other measurable pollutants within a catchall criterion of “Improves Air Quality.” There are eighteen other evaluation criteria for highways, so it appears as though greenhouse gas emissions are not given enough weight relative to the harmful effects of climate change that are expected this century.

For the evaluation of transit projects, greenhouse gas reductions are also considered. Instead of being one of nineteen measures as with highway projects, air quality is one of only seven evaluation criteria for transit project selection. Another key difference is that numerical values are not assigned for each performance measure. Instead, each measure is assigned a rating of high, medium, or low. Because of the subjective rating procedure, it is difficult to say whether each category is given equal weights during evaluation. However, the total rating for each project is consistent with

its ratings for individual performance measures, which suggests that each evaluation criteria is probably of equal weight.

3.2.5.2 City of Denver, Colorado (68)

Denver, like many other large U.S. cities, has recently created its climate action plan, which includes final recommended strategies divided into two categories: primary Denver strategies and suggested regional and statewide initiatives. A strategy or initiative must satisfy a set of evaluation criteria if it is to be included within either recommended category. The evaluation criteria consists of:

- **“Viability** – Is the proposed action financially, technologically, and politically viable?
- **Cost-effectiveness** – Applying full-cost accounting principles, are the distributions of costs and benefits equitable and reasonable?
- **Implementability** – Is there a readiness to implement and are the potential barriers to implementation low?
- **Achievement of goals** – Does the proposed action contribute to short- and long-term reduction goals? Is there a cumulative impact over time?
- **Engagement** – How can the impact potential of the proposed action be balanced with the potential for public engagement and education?”

The action plan does not discuss any ranking methodology or if each measure is given equal weight in the evaluation process. Even though these five evaluation measures are fairly standard and consistent with those of long-range MPO plans, they are included in this discussion to show that climate action plans at the city level still have some evaluation process for selecting preferred strategies. It is important to note that

greenhouse gas emissions are not specifically mentioned here as a measure of evaluation because reducing greenhouse gases already serves as the entire purpose of the document. This is why an evaluation process of a climate action plan, as demonstrated by Denver's plan, may focus specifically on factors such as implementation, cost-effectiveness, viability, and how well each strategy supports the overarching goal of lowering greenhouse gas emissions. Conversely, with long-range transportation plans from MPOs, emissions of greenhouse gases may very well be a component of the evaluation process because their reduction is but one of many goals that the agency may consider.

3.2.5.3 Puget Sound Regional Council (57, 69)

The idea to create *Vision 2040*, the regional growth strategy for the Seattle metropolitan area, was originally discussed when it became apparent that the prior strategy, *Vision 2020*, was beginning to appear out of date. The task of establishing a new strategic growth vision that combined transportation, land use, economic development, and the environment into one plan quickly turned into a search for a preferred growth alternative. The first step by the Growth Management Policy Board (GMBP) was to establish the scope of the document. A scoping report was created, which resulting in twenty issue and information papers based directly on its conclusions. These papers were instrumental in the identification of eight growth scenarios to the year 2040, of which, four growth alternatives were selected for evaluation within the draft environmental impact statement (DEIS):

1. Growth Targets Extended Alternative: This alternative assumes current population and growth patterns will continue over the planning period.

2. Metropolitan Cities Alternative: This alternative focuses most of the growth inside the region's five largest cities—Seattle, Bellevue, Everett, Bremerton, and Tacoma.
3. Larger Cities Alternative: This alternative expects most of the growth to occur within suburban cities and areas.
4. Smaller Cities Alternative: This alternative assumes a disperse growth pattern.

The process of comparing and evaluating the growth alternatives was contingent upon four tools:

- The findings in the DEIS
- The findings developed in the *Public Review and Comment on the Vision 2020 Update Draft Environmental Impact Statement—Summary Report*
- The analysis and recommendations of an interjurisdictional technical panel composed of staff from each of the counties in the region
- Application of evaluation criteria

The evaluation criteria provide a straightforward and systematic method of evaluating growth alternatives for the region. In all, almost 50 individual evaluation criteria over seven topics¹⁸ were used in the comparison. A numerical scoring method was not used in the evaluation process. Instead, at the suggestion of the GMPB, a check mark was used to denote the alternative that best supported each individual criterion. If more than one alternative was considered the best, the tie would permit each “best” alternative to have a check mark. In addition, smaller check marks denoted alternatives

¹⁸ Environmental quality, health, economic prosperity, land use, transportation, environmental justice, and efficiencies in the provision and use of infrastructure, public facilities and service

that came close to acquiring “best” status. The evaluation criteria document makes it clear that suggested rankings from the process are not meant to bind decision-makers, but to inform their selection process of a preferred alternative.

The criteria were designed to mirror the goals and objectives of the region’s growth vision. Subsequently, climate change, as well as transportation measures supportive of emissions mitigation, was included as piece of the evaluation process. Table 3.6 shows the summary of the climate change criteria along with rankings for each of the four alternatives. It is interesting to see that the effects of the climate change are only listed as the rationale for the criteria while adaptation was not mentioned during the evaluation process. Additional transportation and land use criteria relevant to climate change included transit adjacency to population, amount of population in cities with regional growth centers, daily VMT and VHT, travel distance, and overall energy use. The metropolitan cities and larger cities alternatives consistently rated best among these alternatives.

Table 3.6: Climate change evaluation criteria (69)

Measure:	<u>1E. Climate Change</u>			
Unit:	Carbon Dioxide Emissions (<i>based on PSRC's MOBILE 6.2 Air Quality Model data</i>)			
Rationale:	An emerging and consequential issue for our region's people, economy, natural systems, and infrastructure, climate change is affected by human activities. Rising temperatures will impact precipitation, alter forests and crop yields, affect species and the food chain, affect water levels and temperatures, and will affect the region's snow pack.			
Discussion:	In the Puget Sound region, 50 percent of the emissions are attributable to transportation sources. Other sources include industry, agriculture, and landfills. The alternatives that focus growth (such as the Metropolitan Cities and Larger Cities alternatives) and thereby decrease vehicle miles and hours traveled, and reduce estimated levels of delay, are anticipated to generate lower levels of greenhouse gases. These two alternatives are estimated to generate similar amounts of carbon dioxide in 2040, and both are therefore ranked as best.			
Ranking:	Growth Targets Ext.	Metropolitan Cities	Larger Cities	Smaller Cities
		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	

CHAPTER 4

DISCUSSION AND RECOMMENDATIONS

This chapter of the thesis will provide a summary discussion concerning the considerations of climate change in the transportation planning process. Each section of this chapter will focus on a single step of the conceptual planning framework and describe the most important findings. Following the summaries, recommendations concerning the inclusion of climate change considerations into the planning process are presented and clarified. Though not included in the application section of Chapter 3, programming, project development, and system monitoring are discussed and recommendations are offered as well.

4.1 Vision

A vision should set the tone and influence the transportation planning process by assisting in the identification and development of goals, objectives, and performance measures. The vision often reflects the requirements and regulations of federal or state governments and agencies that provide funding to MPOs. MPOs may choose to engage citizens and businesses in a visioning process to further hone a more precise vision that better represents the community's desired outcomes. Additionally, distinguishing transportation trends, issues, and challenges through transportation system monitoring further facilitates the creation of a vision.

As demonstrated in the Chapter 3, MPOs and cities are beginning to include climate change considerations into their visioning process in a variety of ways. The Boston Region Metropolitan Planning Organization, for instance, explicitly mentioned

CO₂ reduction and strategic mitigation policies in their environmental vision, while the climate vision of the Chicago Metropolitan Agency for Planning's long range plan was more general and open ended. Both the BMPO and the CMAP featured public outreach campaigns as portions of their plans, with the CMAP going one step further by holding a visioning event where attendees could electronically vote and express their opinions in response to the visions of the region's upcoming long range growth plan.

In addition to the scope and public input process, the source of a climate change vision could vary from one place to another. The New York Metropolitan Transportation Council decided to compile a list of overarching trends and issues that could influence its long range plan, and mentioned that the driving force behind its climate change considerations is the *New York State Energy Plan*. The City of Boston owes its climate change vision to an executive order from Mayor Thomas Menino, and many hundreds of other cities are now planning for climate change thanks in part to the US Mayors Climate Protection Agreement created by the Mayor of Seattle, Greg Nickels. Clearly, the decision to include climate change into the transportation planning vision can come from a higher office of government. Even MPOs may have a federal basis for a climate change vision.

The SAFETEA-LU federal legislation includes eight planning requirements for long-range transportation planning activities:

1. "Support the economic vitality of the United States, the States, nonmetropolitan areas, and metropolitan areas, especially by enabling global competitiveness, productivity, and efficiency;
2. Increase the safety of the transportation system for motorized and nonmotorized

users;

3. Increase the security of the transportation system for motorized and nonmotorized users;
4. Increase the accessibility and mobility of people and freight;
5. Protect and enhance the environment, promote energy conservation, improve the quality of life, and promote consistency between transportation improvements and State and local planned growth and economic development patterns;
6. Enhance the integration and connectivity of the transportation system, across and between modes throughout the State, for people and freight;
7. Promote efficient system management and operation; and
8. Emphasize the preservation of the existing transportation system” (70)

Though not explicitly mentioned in any of the eight planning requirements, it could be argued that SAFETEA-LU provides the regulatory justification for both climate change adaptation and mitigation considerations in the planning process, especially in light of the Supreme Court ruling of *Massachusetts v. EPA* that concluded tailpipe greenhouse gas emissions can be regulated by the EPA. Planning requirements could provide the basis for mitigating greenhouse gas emissions from transportation sources due to its language concerning environmental protection and energy conservation. This planning requirement already has a large influence on MPOs due to its provision that links transportation and growth planning. Subsequently, many MPOs now include a component of their plan that specifically highlights the need for an inclusive transportation and land use planning process. The USCCSP report, *Impacts of Climate Change and Variability on Transportation Systems and Infrastructure*, presents a similar

observation and mentions that adaptation to climate changes may be reflected in the SAFETEA-LU requirements as well, including “system preservation, system management and operation, safety, and economic vitality (see especially factors 1, 2, 6, and 8)” (8). Perhaps a future transportation bill¹⁹ authorization will include more specific language concerning climate change considerations.

Because a study’s vision is usually influenced by the federal government via SAFETEA-LU, agencies and governments at the metropolitan and local level that are in charge of transportation planning often focus on a limited number of issues and have not generally included climate change as a topic. Several recommendations can be made in terms of encouraging a more focused consideration of climate change in the transportation visioning process:

- a. **Incorporate climate change considerations into the transportation vision in response to the SAFETEA-LU planning requirements.** SAFETEA-LU provides eight general planning requirements that must be met in order to receive federal funding, five of which could be tailored to support mitigation of greenhouse gases (requirement 5) and adaptation to the effects of climate change (requirements 1, 2, 6, and 8). Requirement 8, in particular, presents a great

¹⁹ Though not a transportation bill, *America’s Climate Security Act of 2007* was being debated in Congress as of the finishing of this thesis. The bill, though primarily concerned with a national cap and trade system, also recognizes that further reducing greenhouse gas emissions may require “changes in the vehicle, in the fuels, and in consumer behavior” (71). Under the bill, states are granted emission allowances and will be expected to reduce their overall greenhouse gas emissions through several strategies, one of which is “to improve public transportation and passenger rail service and otherwise promote reductions in vehicle miles traveled” (71). A national adaptation plan is included in the bill as well. The adaptation plan would divide the U.S. into 6 regions for review and include vulnerability and cost assessments for regional infrastructure in addition to “an assessment of climate change science research needs, including probabilistic assessments as an aid to planning” (71).

opportunity for a metropolitan or local agency or government to include climate change adaptation as part of transportation system preservation, which is often a critically important component of a transportation plan's vision.

b. Include adaptation to the harmful effects of climate change on transportation infrastructure, operations, and maintenance in the planning vision.

Transportation visions that relate to climate change are mostly concerned with mitigation of greenhouse gases. Adaptation to the effects of climate change is rarely discussed and is often ignored due to the uncertainties in climate science. However, the science seems to be catching up as more finely tuned information is becoming available at the regional level. As a result, a transportation vision should include a statement concerning a resilient transportation system in the face of climate changes, particularly in metropolitan areas where storm surge and flooding are a greater risk.

c. Engage the public in the visioning process to receive community input concerning a climate change vision. Climate change is becoming an increasingly visible issue within the United States, so communities should be able to provide input for their area's long range visions concerning how transportation influences and responds to a changing climate.

4.2 Goals, Objectives, and Performance Measures

A vision helps direct a government or agency around common concepts so that an area's desired outcomes may be achieved, but the goals and objectives provide the general direction for the transportation planning process. Organizations develop goals that will assist in realizing the planning vision, while objectives are the explicit actions

that are required to meet the defined goals. Performance measures, which are relatively new to transportation systems planning, are metrics developed specifically to assess the functioning of the transportation system relative to the vision, goals, and objectives. Together the goals, objectives, and performance measures are the backbone of the transportation planning process, guiding the data collection, analysis methods, strategy development, evaluation process, and system monitoring.

As with the previous section concerning vision statements, climate change considerations are becoming more prominent in planning goals and objectives. Many of the MPOs and cities that discuss climate change in their plans include goals and objectives pertinent to mitigation or adaptation, though mitigation goals and objectives are far more frequent. Many of these organizations identify greenhouse gas reduction targets. These reduction targets vary greatly, but usually are no less than targets established by the Kyoto Protocol. In some cases, Kyoto targets are greatly exceeded by organizations hoping to become leaders in environmental stewardship or having to respond to national government or state mandates. The most significant greenhouse gas reduction target encountered during this research is from the City of Rotterdam, Netherlands, where they hope to achieve a 50% reduction of emissions below 1990 levels by 2025 (72). However, this goal is misleading because it includes more than just the transportation sector. In fact, 83% of the total reduction is expected to come from industry, with the remaining 17% attributable to transportation and water sectors. This issue is common among greenhouse gas reduction targets. Mitigation of CO₂ is not expected to come from transportation sources alone, but also from industrial and residential sources in addition to improved energy efficiency. An agency or government

will often reveal the sources of reduction by breaking down these targets by economic sector.

Common objectives to meet greenhouse gas mitigation goals include improving vehicle fleet efficiency through technological and fuel alternatives in addition to actions aimed in reducing VMT. Coordinated land use and transportation investment decisions are usually included within goals and objectives, but are often not framed by the issue of greenhouse gas mitigation. Even still, integrating these two planning disciplines into one seamless process remains a goal of many planning organizations across the world.

Adaptation to the effects of climate change is a topic not widely developed when it comes to goals and objectives. The need for adaptation goals and objectives has been made clear by plans that discuss the likely hazards for transportation systems, but the lack of available information and the reliability of climate science are usually cited as impediments to including adaptation considerations in the planning process.

Nevertheless, several organizations are beginning to identify adaptation goals and objectives. Objectives of the City of Berkeley's *Climate Action Plan* identify the need to assess the city's vulnerability to climate change impacts and create an adaptation plan, while the Puget Sound Regional Council and Metrolinx in Toronto discuss aspirations for adaptive planning that would reduce uncertainty over time and eventually result in more resilient infrastructure. Other organizations, such as the Portland Metro, include goals to reduce vulnerability from natural disasters and terrorist events. Such goals could most likely accommodate climate change adaptation quite well.

Because goals and objectives relating to adaptation only identify the need to begin planning for climate change adaptation, performance measures relevant to climate change

are exclusively related to mitigation. The most common mitigation performance measures are characterized by changes in components of transportation operations that directly influence the emissions of greenhouse gases (and that are already measured), such as VMT, number of trips, trip length, and modal split. More direct performance measures include total greenhouse gas emissions per year and energy efficiency and use. Portland's Metro employs an interesting, context-sensitive approach to assessing performance of specially designated mixed-use centers. Instead of using standard congestion-related metrics, these mixed-use centers, or areas of special concern, utilize performance measures that are designed to meet at the intersection of transportation and land use, such as parking ratios and non-SOV modal targets.

MPOs and local governments are starting to develop goals, objectives, and performance measures that are relevant to climate change, but there are still some recommendations to be made:

- a. **Establish greenhouse gas reduction targets.** Greenhouse gas reduction targets provide a means to quantify emissions reduction goals so that tracking mitigation progress is easier to understand. Targets should comply with the Kyoto Protocol at the very minimum. Some organizations include these targets, but many MPOs in the U.S. do not.
- b. **Integrate greenhouse gas mitigation into existing goals and objectives.** Many goals and objectives already in place support reducing greenhouse gases, such as integrating land use and transportation decisions and improving air quality. These goals and objectives could be re-branded to include the mitigation of greenhouse

gases with little or no effect on their influence of the direction of the planning process.

- c. **Integrate adaptation to the likely effects of climate change into existing goals and objectives pertaining to natural disasters, security threats, and preservation of existing transportation infrastructure.** Ideally, adaptation would receive its own set of goals and objectives, but in reality some of the existing goals and objectives are quite similar in concept to reducing vulnerability to the effects of a changing climate. In particular, goals and objectives relating to natural disasters, security threats, and the preservation of existing transportation infrastructure provide a good fit for the inclusion of adaptation to climate change, especially for organizations in coastal regions and northern areas where the most impact is likely to be felt.
- d. **Include performance measures for both mitigation and adaptation that influence and track progress towards meeting climate change related goals and objectives.** Mitigation performance measures are already being incorporated into the planning process, but more can be done. In addition to tracking changes in greenhouse gas emissions, energy use, and travel characteristics, organizations should create metrics that can assess other important topics, including land use and transportation integration, parking supply and ratios, funding for alternative transportation programs and investments, and amount of land consumed for transportation infrastructure. Adaptation performance measures should be created in order to guide the development of appropriate data collection and a risk management process. Adaptation metrics could potentially include the overall

resilience of an area's transportation system to climate effects or the percentage of new infrastructure built outside of identified flood zones or areas of high risk.

Developing adaptation performance measures would first require a risk assessment to identify the types of climate exposure in an area and the vulnerability of its transportation systems.

4.3 Analysis

The first step of any analysis is to collect appropriate data. The types of data required for an analysis depends upon the previously identified performance measures. For example, if an MPO concludes that the change of greenhouse gas emissions over a certain period of time is a performance measure for its mitigation goals and objectives, the analysis process would require data concerning VMT, modal split, regional fleet characteristics, and fuel efficiency, among other data categories depending on the scope and precision of the analysis. The analysis process itself is crucial to transportation planning because it explores the relationships of various planning concerns that affect transportation systems and investigates how changes influence future performance.

The review of organizations has shown that greenhouse gas modeling is beginning to take place. The Atlanta Regional Commission, for example, has recently completed its own greenhouse gas analysis to the planning horizon year of 2030. The ARC used fleet characteristics and average regional fuel economy in conjunction with the EPA's Mobile6 pollution dispersion modeling software to calculate emissions factors. The ARC then utilized its travel demand model and a variety of land use scenarios to estimate future travel growth and VMT in the metropolitan region. By multiplying the VMT and the emissions factors, greenhouse gas emissions over the planning horizon

were estimated. The NYMTC conducted a similar analysis, but instead of using Mobile6, the organization opted to calculate energy use using the travel demand model outputs VMT and speed. The NYMTC then converted the energy use into greenhouse gas emissions.

While mitigation analysis is becoming more detailed and relatively commonplace among transportation planning organizations concerned about climate change, adaptive analysis is difficult to find. The several instances of what could be considered adaptive climate change analysis have primarily been concerned with assessing exposure to flooding. The Brisbane City Council effectively borrowed a report by the Commonwealth Scientific and Industrial Research Organisation [sic] that investigated the exposure to the effects of climate change in the State of Queensland, Australia. The results discussed the projections of Queensland's future climate (shown in Table 3.2) and produced flood maps of the Brisbane area. In London, United Kingdom, the London Climate Change Partnership qualitatively investigated the effects of climate change on London's transportation systems. The report looked into several case studies concerned with heat and flooding and presented qualitative conclusions coupled with recommended actions. None of these analysis methods are definitive in assessing transportation system risks, but they represent a step in the right direction for adaptive planning.

The analysis component of the planning process arguably needs the most updating in terms of climate change considerations. Some recommendations for the analysis process include:

- a. **Incorporate greenhouse gases into air quality modeling and conformity analysis.** Air quality modeling already uses the necessary tools and data required

to estimate metropolitan CO₂ emissions. Including CO₂ emissions as an extra output from this process would allow for projects and strategies to be evaluated based upon their contribution to climate change and would prepare planning organizations if CO₂ becomes a regulated pollutant. Because of this analysis overlap, greenhouse gases emissions should be considered during the conformity analysis process as well. This would require the definition of greenhouse gas emissions targets by the U.S. EPA, which would certainly be a topic of debate among all parties involved.

b. Model land use decisions and their effects on greenhouse gas emissions.

Smart growth is often considered a necessary strategy in reducing greenhouse gas emissions from transportation sources by reducing the need to travel by automobile, creating short trip lengths, and allowing for the use of alternative transportation. Land use decisions should be included in the modeling component of the analysis so their effects on greenhouse gas emissions can be estimated.

c. Collect data concerning exposure to the effects of climate change and the vulnerability of the transportation system. Data collection will be an integral component of an adaptive planning process to assess risks associated with climate change. Data should be collected in order to estimate exposure to the effects of climate change and assess the vulnerability of transportation infrastructure and operations. Admittedly, collecting exposure data involves a certain degree of uncertainty at the metropolitan level, but climate science is steadily becoming more precise for smaller areas (8). An asset management process would best collect vulnerability data. The asset management process would ideally

investigate transportation facilities and result in the knowledge of their conditional characteristics (e.g. condition as a function of its age, structural deficiencies, extent of use throughout service life, etc.) as well as their relationship to their local environment (e.g. a highway located in a flood zone). Together, the exposure and vulnerability will result in the transportation risks from climate change.

- d. **Introduce a risk management planning process into transportation systems planning.** A risk management planning process, as shown in Figure 2.1, is the best analysis framework available to assist in developing adaptation strategies for the transportation system. Organizations are hesitant to begin calculating the transportation risks of climate change due to the lack of data and the uncertainties of climate science at the metropolitan or local level. The risk management process addresses this hesitance through iteration, which will allow for continuous updating of the exposure to the effects of climate change, the vulnerability of transportation facilities and operations, and the resilience of the transportation system as a whole. This process may begin with little knowledge or certainty, but eventually can result in a more comprehensive understanding of how to adapt to a changing climate due to continuous iterations of climate data that is expected to become increasingly more precise (8). The risk management process is discussed with more depth in Chapter 2.
- e. **Develop partnerships to better analyze the relationships between climate change and transportation.** Considering climate change in the transportation planning process is a new concept, which means assessing the risks and

developing mitigation analysis techniques could very well exceed the current ability of transportation planning organizations. Developing partnerships with a variety of agencies, organizations, and governments could provide helpful data and analysis techniques. For instance, BCC received its exposure projections from the CSIRO, a national Australian organization, and New York City is working in conjunction with the Federal Emergency Management Agency to finalize its maps of flood risk. In addition, MPOs sometimes turn to a state for help with greenhouse gas analysis (provided the state requires such an analysis) while cities often look to the International Council for Local Environmental Initiatives to help with their analysis.

4.4 Strategies

The analysis process for most transportation planning organizations includes a set of strategies that are examined by various analysis tools. In this case, strategy is a general term that can vary by organization depending on its transportation planning process. Strategies can represent transportation projects, alternative plan scenarios, or alternative improvement strategies. The results of analyzing these strategies will then supply information to the evaluation process.

A common approach of organizations with respect to greenhouse gas emissions is to create a set of alternative scenarios, each with its own unique combination of projects and alternative improvement strategies, and analyze the strategies' greenhouse gas emissions. These alternative scenarios are never solely focused on lowering greenhouse gas emissions, but reducing these gases may be more predominate in one scenario over another due to the differing strategies and transportation projects included. Toronto's

Metrolinx utilized this alternative scenario approach for analyzing its strategies, and found that one of its three growth scenarios is predicted to meet Ontario's reduction target of 20% below 1990 levels by 2020. Metrolinx is not the only organization cooperating with higher levels of government. Other organizations (e.g. the NYMTC and the SJCOG) have identified alternative transportation strategies that are supportive of their respective State requirements as well.

Identifying strategies can also be an iterative process, as demonstrated by Transport for London. For its *Transport 2025* plan, the TfL initially conducted a greenhouse gas analysis of one scenario, known as the Reference Scenario, and concluded that this scenario would not come close to realizing the Mayor's greenhouse gas reduction goal. In response, TfL identified six strategies to help rise above the limitations discovered in the Reference Scenario. One of these strategies was focused on providing new capacity primarily in the form of public transportation, so the TfL created three additional capacity expansion scenarios and re-ran the analysis versus the Reference Scenario. The agency found that the final scenario, which included the most expansion of public transportation, came the closest to meeting the Mayor's greenhouse gas reduction goal.

Based on the reviewed online material, climate change adaptation strategies from any organization are difficult to find. This may come as no surprise since none of the reviewed organizations utilize an adaptive climate analysis process based on risk management. Still, in its sustainability document, *PlaNYC*, New York City identified three general adaptation strategies that will assuredly incorporate considerations for the transportation system. Based on one of the adaptation strategies, New York City will

create a Climate Change Advisory Board with a purpose of producing an adaptive planning framework for the Office of Long-Term Planning and Sustainability. The framework will be centered on a risk management and cost-benefit analysis through the use of explicit performance measures, but first will require a scoping study to define a planning methodology. Additionally, the *New York State Energy Plan* includes language that suggests adaptation strategies for transportation infrastructure could possibly appear in future NYMTC plans.

Based upon the review of available plans, some recommendations for the development of strategies pertaining to climate change include:

a. **Develop adaptive strategies as part of a risk management analysis process.**

The output of a risk management analysis process is a set of adaptive strategies, as shown in Figure 2.1. After the analysis, planners and decision makers may decide to protect, accommodate, or retreat transportation facilities and operations in response to the risk involved with the effects of climate change. Adaptive strategies are discussed with more depth in Chapter 2.

b. **Include a climate change alternative in scenario planning.** Scenario planning is gaining popularity among organizations because it allows for a direct comparison between alternative growth scenarios. Each scenario is based upon differing transportation investment decisions that are assumed to meet the growth expectations over the planning horizon. Where transportation investments are made can have a measurable impact on population growth patterns, which in turn influences emissions of greenhouse gases and could potentially affect the risk to climate change consequences in certain areas. Some organizations already

include greenhouse gas emissions in their scenario analysis, as demonstrated in Chapter 3, but the scenarios themselves are not focused specifically on transportation and climate change. Perhaps the inclusion of an alternative scenario focused on climate change mitigation and adaptation would be beneficial for the analysis and evaluation steps in the planning process. By comparing the results of a climate change scenario with other planning scenarios, organizations could achieve a better understanding of how their transportation investment decisions affect and respond climate change, assuming the organization possesses a valid model and appropriate data.

- c. **Include the reduction of greenhouse gas emissions within the scope of CMAQ²⁰ transportation control measures.** Transportation control measures (TCM) are alternative transportation strategies that aim to reduce the emissions of harmful tailpipe pollutants and are required for all non-attainment areas. Some of the most common TCMs attempt to reduce single occupancy driving and assist in providing transportation alternatives. Greenhouse gas reductions should be defined within the scope of TCMs since these strategies already help reduce all types of vehicle emissions.
- d. **Reconsider performance measures.** The conceptual transportation planning framework in Figure 2.1 shows that strategies are not just a part of the analysis process, but that they can influence the development and identification of performance measures as well. In response to their strategies, organizations should investigate their performance measures to determine whether redefining

²⁰ Congestion Mitigation and Air Quality Improvement Program

their metrics could better monitor transportation performance. Such a reevaluation may be especially important with adaptive climate change strategies since the risk management analysis will be quite new to most organizations.

4.5 Evaluation Process

The evaluation process compares alternatives based on the results of the analysis in conjunction with benefits, costs, and other financial constraints so that projects and strategies that best address the vision, goals, and objectives are included in the resulting transportation plan. There are many characteristics of the evaluation process, which are discussed in Chapter 2, but one of the most common components of the process are the criteria by which alternatives are evaluated. Evaluation criteria are meant to reflect the performance measures identified earlier in the planning process and would ideally contribute to the identification of appropriate data and analysis tools.

The review of available planning documentation for this report has shown that MPOs are often not considering climate change in their evaluation process, but when they do, the mitigation of greenhouse gases appears to be the only relevant evaluation criteria. The BMPO and the PSRC are the best examples of including greenhouse gas mitigation in the evaluation process. The BMPO evaluates all of its highway and transit projects before they can be included in the final recommended transportation plan, but highway and transit criteria are different. Highway projects are evaluated over 18 different categories, including air quality (which includes CO₂), with each category receiving a score ranging from -3 to 3. Transit projects, on the other hand, are not assigned scores but are instead evaluated qualitatively over only seven categories (which includes air quality), meaning that CO₂ emissions reductions are given a larger weight for transit

projects than highway projects. With the PSRC, assessing its four growth alternatives was based upon several evaluation tools, one of which was a defined set of evaluation criteria. The criteria included the mitigation of greenhouse gas emissions in addition to other supportive measures such as travel characteristics, energy use, and land use.

Other MPOs that identified climate change as a transportation challenge decided to compare and contrast projects and alternatives with more general environmental, air quality, and land use evaluation criteria. While many of these metrics are related to greenhouse gas emissions, it is often the case that explicit CO₂ measurement criteria are omitted. This is most likely a result of a lack of required data and analysis tools to estimate future emissions.

In contrast to greenhouse gas reduction competing with other performance metrics within MPO plans, the evaluation criteria for municipal climate action plans do not include climate change considerations because addressing climate change is already the defined purpose of the document. Subsequently, strategies can be evaluated based upon other criteria such as implementation, cost-effectiveness, and viability, which is from the *City of Denver Climate Action Plan*.

Based upon the review of available plans, some recommendations for the evaluation process are:

- a. **Include the mitigation of greenhouse gases as part of the air quality, transportation alternatives, and land use evaluation criteria.** Evaluation criteria for air quality, transportation alternatives, and land use are fairly common among planning organizations and they directly influence the mitigation of

greenhouse gases. The evaluation process should consider CO₂ reduction in each of these criteria instead of a single, separate measure.

- b. **Include adaptation to the effects of climate change as part of the safety, security, and preservation evaluation criteria.** Criteria for safety, security, and preservation of existing transportation system are always included in a generalized evaluation process that reflect competing goals and objectives. Because adapting to the likely threats of a changing climate affects transportation safety, security, and system preservation, these three evaluation criteria should consider climate change adaptation during the evaluation process.
- c. **Assign weights to the evaluation criteria so that projects and strategies that adapt or mitigate climate change are more often included in the final transportation plan.** Assigning weights to the evaluation criteria would vary from organization to organization, but criteria that include climate change adaptation or mitigation should be given more weight during the evaluation process due to the expected threats posed from climate change.

4.6 Programming

The prioritization of projects for implementation is known as programming, and the transportation improvement program is the resulting document from this process. A TIP has an implementation timeline of only a few years; consequently, the document is updated every one to two years. The prioritization process is very similar to the evaluation process, except that other factors are considered in conjunction with evaluation criteria. For instance, projects are often evaluated by feasibility, costs, matching funds, and compatibility with state and federal requirements.

The programming process was not reviewed in Chapter 3 because information regarding climate change and project programming proved too difficult to find through a preliminary Internet search.

a. **Grant higher priority to transportation projects that reduce greenhouse gas**

emissions. In non-attainment areas, CMAQ TCMs are given funding priority before any capacity expansion projects. The same urgency should be assigned to projects that have been shown during the analysis process to reduce greenhouse gas emissions. This urgency, or higher prioritization, should not be limited in non-attainment areas only.

b. **Include climate change adaptation as a component of system preservation.**

Thanks to the SAFETEA-LU legislation, the preservation of the existing transportation system is often given the highest priority during the programming process. Projects and strategies intended to help adapt to the effects of climate change would facilitate the preservation the transportation system by making it more resilient over time. For this reason, climate change adaptation should be included as a component of system preservation so that it may receive the highest priority.

c. **Assign weights to the prioritization factors so that projects and strategies**

that address climate change are more likely to be implemented. This recommendation is very similar to the recommendation for the evaluation process. The programming process often includes a method of scoring projects by assigning weights to certain prioritization factors that reflect the organization's

goals. The serious and likely threats of climate change should be expressed by assigning larger weights to climate change prioritization factors.

- d. **Create a prioritization factor that evaluates consistency with other climate change plans and initiatives.** There are many climate change plans and initiatives nationally and globally. The prioritization process should factor a project's consistency with other relevant climate change plans or initiatives. For example, the NYMTC's TIP is to be consistent with the *New York State Energy Plan*, which contains relevant greenhouse gas mitigation goals.

4.7 Project Development

Because the scope of this report is only concerned with transportation systems planning, project development was not considered during the review of online material. However, further gains in addressing climate change through transportation can be made during the project development process. A few general recommendations are:

- a. **Incorporate actions that reduce greenhouse gas emissions during project development and implementation.** There are numerous options available for project development and implementation that would reduce greenhouse gas emissions, such as using recycled materials, incorporating low carbon cement mixtures, utilizing alternatively fueled vehicles, and purchasing locally or regionally manufactured materials, just to name a few.
- b. **Incorporate adaptive design considerations during project development and implementation.** As discussed in Meyer's *Design Standards for U.S. Transportation Infrastructure: The Implications of Climate Change*, engineers could address the risks of climate change when developing new transportation

facilities. Components of infrastructure that could be considered for climate change adaptation that are mentioned in the report include “subsurface conditions, materials specifications, cross sections, drainage, structures, and location engineering” (9). Other adaptive considerations of the report are modular construction methods and technologies that are expected to influence facility design in the future, such as “advances in material sciences (with special application of nano-technologies), sensors, computer processing and communications abilities” (9).

4.8 System Monitoring

System monitoring represents the feedback loop in the transportation planning process. System monitoring uses the performance measures established earlier in the process to supervise the functioning of the transportation system and the effectiveness of the planning process in realizing an organization’s vision, goals, and objectives. One of the better examples of monitoring climate change through the planning process comes from the PSRC, where in addition to monitoring greenhouse gas emissions, the organization also tracks the efforts of local jurisdictions in addressing climate change in their own plans and programs (57). Additionally, efforts to monitor CO₂ emissions are often built into the vision and scope of municipal climate plans, as is the case with New York City’s *PlaNYC* where the results of system monitoring will influence future updates to the plan.

Based upon the review of available plans, some recommendations for system monitoring include:

- a. **Continually monitor efforts to mitigate greenhouse gas emissions.** Tracking the efforts to mitigate greenhouse gas emissions should include monitoring of the emissions, the source of the emissions (fuel types, vehicle efficiency and technology, and travel behavior), the strategies and projects aimed at reducing emissions, consistency with other climate plans and initiatives, and mitigation related project development actions.
- b. **Continually monitor and redefine the exposure to the effects of climate change as well as the vulnerability and resilience of the transportation system.** Even though efforts to adapt to climate change are quite rare, some organizations are beginning to create an adaptation planning process that will eventually recommend the implementation of adaptive strategies. Continually monitoring these strategic efforts will be a necessity if the adaptive planning process is to stay relevant. The risk management framework shown in Figure 2.1 includes a feedback loop so that the definitions of vulnerability and resilience can be continually updated and reflect these latest adaptive strategies. In addition, climate probabilities and projections must be monitored so that the definition of exposure will remain relevant as well.

4.9 Summary

The review of climate change considerations in the transportation planning process has revealed that addressing climate change remains outside the scope of many of the nation's largest MPOs, though many domestic and international cities have expressed concern on the issue and are developing their own climate action plans. The mitigation of greenhouse gases remains the most common approach of addressing climate change

throughout the planning process, while adaptation to the effects of a changing climate is frequently neglected due to lack of data and analysis procedures. Consequently, recommendations for the transportation planning process based on the observations of reviewed material from many organizations were presented and discussed in this chapter. Table 4.1 summarizes these recommendations by individual steps in the planning process.

Table 4.1 Summary of recommendations to incorporate climate change considerations into the transportation planning process

Planning Step	Recommendation
Vision	4.1.a Incorporate climate change considerations into the transportation vision in response to the SAFETEA-LU planning requirements
	4.1.b Include adaptation to the harmful effects of climate change on transportation infrastructure, operations, and maintenance in the planning vision
	4.1.c Engage the public in the visioning process to receive community input concerning a climate change vision
Goals, Objectives, and Performance Measures	4.2.a Establish greenhouse gas reduction targets
	4.2.b Integrate greenhouse gas mitigation into existing goals and objectives
	4.2.c Integrate adaptation to the likely effects of climate change into existing goals and objectives pertaining to natural disasters, security threats, and preservation of existing transportation infrastructure
	4.2.d Include performance measures for both mitigation and adaptation that influence and track progress towards meeting climate change related goals and objectives

Table 4.1 continued

Planning Step	Recommendation
Analysis	4.3.a Incorporate greenhouse gases into air quality modeling and conformity analysis
	4.3.b Model land use decisions and their effects on greenhouse gas emissions
	4.3.c Collect data concerning exposure to the effects of climate change and the vulnerability of the transportation system
	4.3.d Introduce a risk management planning process into transportation systems planning
	4.3.e Develop partnerships to better analyze the relationships between climate change and transportation
Strategies	4.4.a Develop adaptive strategies as part of a risk management analysis process
	4.4.b Include a climate change alternative in scenario planning
	4.4.c Include the reduction of greenhouse gas emissions within the scope of CMAQ transportation control measures
	4.4.d Reconsider performance measures
Evaluation Process	4.5.a Include the mitigation of greenhouse gases as part of the air quality, transportation alternatives, and land use evaluation criteria
	4.5.b Include adaptation to the effects of climate change as part of the safety, security, and preservation evaluation criteria
	4.5.c Assign weights to the evaluation criteria so that projects and strategies that adapt or mitigate climate change are more often included in the final transportation plan
Programming	4.6.a Grant higher priority to transportation projects that reduce greenhouse gas emissions
	4.6.b Include climate change adaptation as a component of system preservation
	4.6.c Assign weights to the prioritization factors so that projects and strategies that address climate change are more likely to be implemented
	4.6.d Create a prioritization factor that evaluates consistency with other climate change plans and initiatives
Project Development	4.7.a Incorporate actions that reduce greenhouse gas emissions during project development and implementation
	4.7.b Incorporate adaptive design considerations during project development and implementation

Table 4.1 continued

Planning Step	Recommendation
System Monitoring	4.8.a Continually monitor efforts to mitigate greenhouse gas emissions
	4.8.b Continually monitor and redefine the exposure to the effects of climate change as well as the vulnerability and resilience of the transportation system

CHAPTER 5

CONCLUSION

There is a common agreement among most scientists that climate change is real, has already begun, and can have serious implications on a wide variety of natural and human systems. Given the relationship between transportation and greenhouse gas emissions, the linkage between climate change and transportation is particularly evident and must be addressed through strategies that seek to mitigate transportation-related greenhouse gas emissions and adapt transportation systems to the threats of a more inhospitable climate. Incorporating climate change considerations into the transportation planning process would provide the opportunity for transportation planners and decision makers to best develop such strategies.

The review of readily available transportation plans and related documents of 60 major MPOs, 13 domestic cities, and 27 large international cities revealed that climate change considerations are often not incorporated into the planning process, especially in regard to adapting transportation systems to the effects of climate change due to the inherent uncertainties in climate data and risk analysis. Only several organizations have begun developing adaptation methodologies and plans. On the other hand, greenhouse gas mitigation is more frequently included in the planning process, when compared to climate change adaptation, because the required data collection techniques and analysis tools are better developed and already in place within many planning organizations.

There is much room for improvement in terms of incorporating climate change into transportation planning, which is why recommendations for each step of the planning

process are presented in Table 4.1. Many of the recommendations have shown that climate change adaptation and mitigation could be worked into existing planning requirements, processes, and strategies at the metropolitan and local level. However, due to the influence by federal and state governments on the planning process, completely addressing climate change through transportation systems will require these high levels of government to redefine transportation regulations and planning requirements in addition to partnering with MPOs and local governments to develop and increase the availability of more reliable climate data. The political nature of climate change ensures that implementing many of these recommendations will be quite difficult, but the urgency of the issue demands that climate challenges must soon be addressed or the opportunity to make a meaningful and lasting difference will have slipped away.

5.1 Recommendations for Future Study

This research represents an initial investigation of climate change and transportation planning for MPOs and select domestic and international cities through the review of transportation plans. The scope of the report is limited to surface transportation, predominantly large planning organizations, and publicly available online planning documentation. Consequently, there are several avenues of further research that should be explored:

- A more comprehensive study of climate change and the transportation planning process that includes surveys, interviews, and a more in-depth review of planning procedures of MPOs and cities
- A more comprehensive comparison between domestic and international regional planning organizations

- Freight planning and climate change
- Aviation and maritime planning and climate change
- Transportation planning and climate change for medium and small MPOs
- Cost-effectiveness of incorporating climate change considerations into transportation planning

APPENDIX A
CASE STUDIES

A.1 Metropolitan Planning Organizations

A.1.1 Boston Metropolitan Planning Organization (BMPO) (43, 73)

In chapter 10 of the BMPO's *Journey to 2030* long-range transportation plan, CO₂ is highlighted as a greenhouse gas that promotes global warming and climate change. The document cites two recent breakthroughs concerning climate change: the Regional Greenhouse Gas Initiative and the recent Supreme Court case of *Massachusetts v. EPA*. The Regional Greenhouse Gas Initiative is a multi-state initiative whose immediate function is to reduce greenhouse gas emissions from power plants, but eventually the plan will include other sources of emissions (possibly transportation). Emissions reduction will be possible through a cap-and-trade program. The Supreme Court case ruled that EPA has the ability to regulate greenhouse gases from automobiles. *Journey to 2030* suggests this could have large consequences on how CO₂ and other greenhouse gases are regulated, and the plan states it "will continue to support projects and programs that reduce emissions of CO₂ in the region." The plan also suggests "global warming may alter the region's temperature and rainfall patterns and will increase the need for renewable energy technology."

According to the *Unified Planning Work Program*, an ongoing compliance project with SAFETEA-LU states "staff also maintain expertise in environmental issues, including climate change."

A.1.2 Capital Area Metropolitan Planning Organization (CAMPO) (74)

The *2030 Long-Range Transportation Plan* by the Capital Area MPO discusses how the Triangle area has the 23rd worst air quality of any metropolitan area in the

country, but the “discussion of greenhouse gases (primarily carbon dioxide) and global warming have not yet entered into the local environmental limelight, probably due to their unregulated status.” The plan was finished in 2005, two years before the Supreme Court case of *Massachusetts v. EPA*.

A.1.3 Chicago Metropolitan Agency for Planning (CMAP) (47, 48, 75)

One of the main goals in CMAP’s *Shared Path 2030* is to “employ transportation to sustain the region’s vision and values.” Within this goal statement, CMAP stresses the relationship between transportation and a sustainable environment while specifically citing climate change as an area of concern. The agency proposes an integrated land use and transportation framework as a solution and expects to have such a framework by 2010.

Part of the current regional vision statements states “the region will actively mitigate the environmental effects of its activities—including climate change—and will be prepared to adapt to future environmental conditions.” So far in the vision statement revision process this statement remains identical. CMAP is also looking into the future for their 2040 *Regional Comprehensive Plan*. The agency held a summit in December 2007 titled *Creating a Regional Agenda to Address Climate Change*. The summit addressed climate change from the perspective of infrastructure, economy, health, and transportation.

A.1.4 East-West Gateway Coordinating Council (EWGCC) (76)

Global warming is mentioned in the larger context of sustainable development in the *Legacy 2035* plan, meaning strategies deal directly with overall sustainability and not specifically with climate change. EWGCC has started the *Gateway Blueprint Initiative* to

help establish long-term design at the local level and also began the *Great Streets Initiative* to promote streets as place-makers, economic engines, and a means to greater mobility/transportation alternatives instead of getting from A to B as quickly as possible.

Some of the more relevant strategies pertaining to climate change include:

- “Support the Clean Cities Program and promote alternative fuel use in major public and private vehicle fleets
- Support the Midwest High Speed Rail initiative and the continuation of passenger rail services in the region
- Promote transportation and development actions that reduce the need for travel, especially single occupant vehicle travel
- Encourage high-density, mixed use development at appropriate MetroLink stations”

CMAQ funds are to finance transportation control measures and other projects that promise the highest reductions in congestion and vehicle emissions in the most cost-effective manner

A.1.5 Greater Buffalo-Niagara Regional Transportation Council (GBNRTC) (77)

Climate change as a largely accepted issue is introduced as a planning assumption similar to population forecasts or employment patterns in the GBNRTC’s *2030 Long Range Transportation Plan*. A statement about a possible future sums up the planning assumption very well: “Serious public policy directed at reducing CO₂ emissions would likely involve a change to current incentives for certain fuel and proposition types, increase the public commitment to alternative modes, and accelerate the movement to strategies such as growth management, development practices and other activities.” The

GBNRTC developed goals and objectives “to identify projects that would impact the region in a positive way.” One of the objectives deals directly with climate change and states the project must “reflect the issues of climate change, the need to reduce the nation’s reliance on foreign oil, and the New York State Energy Plan.”

One of the plan’s three scenarios, called the trend scenario (where current trends are projected out into the future), has population decreasing by 14% and public transportation usage dropping an astonishing 46%. This forecast is bleak, and the plan mentions that such a large decrease in public transportation usage would “result in increased motor vehicle pollutant emissions, exacerbating global warming.”

Additionally, CO₂ emissions as a cause for potential climate change are mentioned in the *Energy and Greenhouse Gas Analysis*.

A.1.6 Houston-Galveston Area Council (H-GAC) (78)

The H-GAC’s *2035 Regional Transportation Plan* has a one-page section devoted to transportation and climate change. The plan recognizes that climate change, through potential sea level increases and possible extreme weather conditions, may have impacts on the transportation system. Realizing the Houston area’s vulnerability to a rising sea level, the plan states impacts on the “regional transportation system include changes in the safety, operations, and maintenance of the region’s transportation infrastructure and systems.” The H-GAC is working with the state DOT to develop a plan to adapt to any future climate change-related issues. The agency is not only concerned with adapting to future challenges but is also looking into mitigating climate change in the present. The plan asserts the next step “in linking transportation and climate change to the transportation planning process will be an increased recognition of the contributions of

the transportation system to GHG emissions and potential strategies to reduce, mitigate, and eliminate these emissions.” The region’s Clean Air Initiatives program is cited as a measure already in place in addressing climate change.

A.1.7 Metropolitan Transportation Commission (MTC) (79, 80)

Transportation 2035 Change in Motion is not finished yet, but according to the MTC website the plan will address questions such as “How should we reduce greenhouse gas emissions from transportation sources and respond to the effects of global warming already underway?” Aside from the long-range plan, the MTC takes the issue one step further by dedicating an entire webpage to all things related to climate change and transportation. The page features several examples of addressing climate change in the Bay Area, such as demonstrating clean fuel buses, removing transit fares during smog alert days, and starting a Climate Protection Summit that created a climate protection draft action plan. The recommendations from the draft action plan are comprehensive, with 18 recommendations from 4 agencies working together. There are too many recommendations to list, but the six strategy elements related to the goals are:

1. Establish priorities;
2. Increase public awareness and motivate action;
3. Provide assistance;
4. Reduce unnecessary driving;
5. Prepare to adapt;
6. Break old habits;

A.1.8 Mid-America Regional Council (MARC) (81)

Under the goal statement “support a quality built and natural environment,” the MARC’s *Transportation Outlook 2030* mentions that CO₂ is the leading contributor to global warming. The plan mentions that replacing automobile trips under 2 miles (which accounts for a large share of all trips) with non-motorized transportation would help reduce CO₂ since most of the greenhouse gas emissions is from the first few minutes of operating an automobile.

A.1.9 New York Metropolitan Transportation Council (NYMTC) (50, 61, 82, 83)

The NYMTC’s *2005-2030 Regional Transportation Plan* mentions climate change as an “overarching issue” considered when developing the plan. Like the Buffalo plan, the NYMTC mentions climate change in the context of the *New York State Energy Plan*. The energy plan is similar to the Kyoto protocol in that it calls for a reduction of greenhouse gas levels to a certain percentage below 1990 levels. Most of the energy plan’s hopeful greenhouse gas reductions are due to new or efficient technologies, but some objectives call for funding energy-efficient transportation alternatives and funding policies to reduce sprawl.

The NYMTC’s *Annual Report 2007* has a specific goal of “reducing our city’s global warming emissions by more than 30% by 2030, a target we know is achievable even just using technology that exists today.” This goal was again reiterated in the *NYMTC Annual Meeting—March 15th, 2007*.

A.1.10 North Jersey Transportation Planning Authority (NJTPA) (84, 85)

The NJTPA does not mention global warming or climate change in any of their planning documents, but several pages on their website mention the issue. One page suggests the use of alternative fuels helps slow climate change as a benefit to the area.

The agency discusses the use of alternative fuels in the context of its Transportation Clean Air Measures initiative. The initiative is an attempt to improve air quality in the northern New Jersey area by reducing emissions. Another page, titled *Are We There Yet?*, is an online version of a document that highlights progress in the northern New Jersey area. One of the goals is to “protect and improve the quality of natural ecosystems and the human environment.” This goal specifically mentions several pollutants as contributors to global warming, though strangely CO₂ is not listed. The pollutants it mentions are CO, volatile organic compounds, and nitrogen oxides. The page shows an impressive decline in emissions of these three pollutants at around 40% of 1990 levels.

A.1.11 Portland Metro (53)

Climate change, along with economic globalization, funding shortfalls, and an aging population, is listed as one of the main issues that need addressing in Metro’s *draft 2035 Regional Transportation Plan*. The issue of a warming climate is taken seriously by Metro and is listed as one of the five main challenges: “Climate change poses a serious and growing threat to Oregon’s economy, natural resources, forests, rivers, agricultural lands, and coastline.” The plan recognizes transportation as one of the main contributors of greenhouse gases in the region and acknowledges the large future escalation in emissions from an increased population. Consequently, “new regulations to reduce emissions associated with climate change are likely in the RTP’s planning horizon, which would put more emphasis on less polluting transportation modes.”

A.1.12 Puget Sound Regional Council (PSRC) (57, 86, 87)

The PSRC’s *Vision 2040* is more than a transportation planning document. It is billed as a growth strategy for the region that integrates planning for the environment,

transportation, public services, economy, and development patterns. The plan's overarching goal for the environment demonstrates this inclusive planning approach: "The region will care for the natural environment by protecting and restoring natural systems, conserving habitat, improving water quality, reducing greenhouse gas emissions and air pollutants, and preparing for climate change impacts. Planning at all levels should consider the impacts of land use, development patterns and transportation on the regional ecosystem."

Vision 2040 states that climate change can potentially impact anything discussed in the plan. The PSRC states they are committed to "address climate change," and this is apparent in a sustainable objective that declares they will "reduce the impacts of transportation on air quality and climate change." Another goal statement mentions "the region will reduce its overall production of harmful elements that contribute to climate change," and this not only deals with transportation but buildings as well. Climate change is considered in other aspects of planning, such as potential impacts on the water supply and how growth management and land use affects the warming of the atmosphere. The policies discussed are reinforced in the document titled *The Environment:*

Multicounty Planning Policies and Actions

Poor air quality and climate change are cited as products of transportation, and the plan says it will look into sensitive areas located around freeways, such as hospitals and schools, when reflecting upon projects that will increase capacity. Growth management is seen as a tool to help curb poor air quality and is emphasized by the Puget Sound Clean Air Agency (a group that is actively developing strategies for addressing climate change).

Cities and counties in the region such as Seattle, Bremerton, Tacoma, and King County are developing action plans in accordance to the Kyoto Protocol.

A.1.13 Sacramento Area Council of Governments (SACOG) (88, 89)

In the currently adopted *Metropolitan Transportation Plan 2025* by the SACOG, environmental sustainability is listed as one of the ten guiding principles of the document. The guiding principle states that while climate change is discussed in the context of sustainability, global warming “remains poorly understood” and strategies on how to solve the issue are difficult to develop. While the plan admits current development and transportation patterns will more than likely continue in the coming decades, measures seen as positive mitigation efforts against climate change currently exist, such as Sacramento’s air quality program and the preservation of open space.

The issue is addressed to a higher degree in the newly released *Draft Metropolitan Transportation Plan for 2035*. A new policy statement says “SACOG intends to use the best information available to implement strategies and projects that lead to reduced Green House Gas (GHG) emissions.” Strategies within this policy guided by climate change include education and outreach on climate change, a plan to help local governments with alternative fuels, and to create a regional action plan on climate change. Reversing the tone of uncertainty set in the *MTP 2025* plan, the new draft declares “The consumption of fossil fuels such as gasoline, diesel, and natural gas by motor vehicles has been shown by scientists to lead directly to global climate changes.” New technologies and modifying travel behavior are viewed as the only solutions in curbing the warming of the atmosphere. Unfortunately, the plan

acknowledges clean-burning fuels and very efficient automobiles will take a long time to develop, and modifying travel behavior “is difficult and often controversial.”

A.1.14 San Joaquin County Council of Governments (SJCOG) (62)

The *2007 Environmental Impact Report* for the *Regional Transportation Plan* mentions climate change extensively. Under the Air Quality chapter, the projects in the regional transportation plan “are unlikely of a sufficient scale to significantly affect global climate change.” The EIR comes to this conclusions based upon the global nature of climate change. It states that because California accounts for 2% of global emissions and the Stockton region has 1.7% of California’s total population, the total global contribution of Stockton is only 0.03% of global emissions. With the assumption that population is proportionate to emissions, 0.03% of global emissions is not considered significant. However, the report does mention that “climate change is a significant global cumulative impact that could also have substantial effect on the natural environment of California and within San Joaquin County.” It then comes to the conclusion that the project’s “contribution to impacts... is considered less than cumulatively considerable.”

A.1.15 Southern California Association of Governments (SCAG) (90)

The State of the Region 2006 report from the SCAG begins with an executive summary of all current transportation issues, and one is identified as the release of greenhouse gases that contribute to global warming and climate change. The report also suggests the need to plan for potential impacts of climate change, especially in the areas of water quality and rising sea levels. Mitigation efforts are reported in terms of the Governor’s Executive Order S-3-05, which states that emission levels should eventually be reduced to 80% below 1990 levels by 2050. The *California Global Warming*

Solutions Act requires “the California Air Resources Board to adopt the statewide greenhouse gas emission limit equivalent to the statewide greenhouse gas emissions levels in 1990 to be achieved by 2020.”

A.2 Domestic Cities

A.2.1 Berkeley, California (55, 91, 92, 93)

Slightly over a decade ago, the City of Berkeley approved its first global warming plan, titled *City of Berkeley Resource Conservation and Global Warming Abatement Plan*. The overarching goal of the plan is to cut greenhouse gas emissions by 15% of 1990 levels by 2010, and “the primary transportation goal of the City of Berkeley is to discourage driving without adversely affecting local businesses.” Berkeley discourages automobile use through restricting parking and refusing to widen roadways.

Transportation accounted for 45% of all greenhouse gases in Berkeley at that time.

Strategies (each with multiple objectives) are proposed for the transportation sector and include trip reduction (primarily through public transit, cycling, and parking policies), land use integration, fleet modernization, traffic efficiency, traffic calming, electric and alternative fuel vehicle use, and investment in bicycle infrastructure. Each strategy is checked to see if it is currently being implemented or if it is feasible to do more. All strategies are identified for near-term or long-term implementation if declared feasible.

So far the strategies appear to be working. Greenhouse gases in the Berkeley area were found to have dropped approximately 9% from 2000 to 2005, which equates to a 61,000 ton reduction of CO₂.

More recently, in November, 2006, a ballot measure, known as *Measure G*, was approved by the people of Berkeley that aims to reduce greenhouse gas emissions by

80% of 2000 levels by 2050. The approval of *Measure G* spawned the creation of the Berkeley Climate Action Team, which is funded by the San Francisco Foundation and managed by the City, and the development of the *Berkeley Climate Action Plan*. The new plan is in draft form and has not yet been finalized due to the public input period that started in late January, 2008. Transportation-related actions of the draft plan resemble the strategies developed for the *Global Warming Abatement Plan* a decade ago, such as encouraging public transportation, developing bicycle and pedestrian infrastructure, municipal fleet modernization, promoting alternative fuel and electric vehicles, and “ensur[ing] that local land use policies are consistent with the goal of making alternative modes of transportation the mainstream.” A few interesting recommended actions include a “hire Berkeley” campaign that intends to persuade local businesses to hire Berkeley residents so that travel and greenhouse gases are reduced, and an aggressive residential parking policy that may reduce or completely remove parking requirements for new housing as well as raise meter and residential parking permit prices in areas where “appropriate and possible.”

A.2.2 Los Angeles, California (94)

Approved in May 2007, *Green LA: An Action Plan to Lead the Nation In Fighting Global Warming* is the City of Los Angeles’ official climate change document. The horizon for this plan only extends to 2030, but by that point the city hopes to reduce its greenhouse gas emissions by 35% from 1990 levels. For transportation, the specific strategies include reducing “carbon intensity” of public vehicles through alternative fuels (both municipal fleet and MTA buses), “focus[ing] on mobility for people, not cars,” linking land use and transportation decision making (such as transit oriented

development), and attempting to “green” both the port and all Los Angeles area airports. The plan calls for efforts to look into methods of reducing CO₂ emissions from aircraft.

A.2.3 Sacramento, California (95)

Sacramento’s draft sustainability plan, titled *Creating a Sustainable City: A Master Plan to Move the City of Sacramento Towards Sustainability*, is a concise document that contains climate change and transportation objectives, among others. The main goal for climate change is to comply with the *Global Warming Solutions Act*, a California law passed in 2006 that aims to reduce emissions to 1990 levels by 2020, for municipal actions and the entire region. Ultimately, Sacramento’s greenhouse gas reduction target is 80% below 1990 levels by 2050, with an interim target of 25% below 1990 levels by 2030. Transportation-related goals of the plan recognize the link between transportation and land use. The City plans to partially combat climate change through transportation by getting people out of cars and into nearby transit, supporting transit oriented development, and “providing a wide array of transportation and housing choices near jobs for a balanced, healthy City.” Specific targets relating to these goals include working towards a transit system accessible to every citizen, “aggressively” applying the SACOG’s *Blueprint* to City plans, and annually expanding bicycle and pedestrian infrastructure by 5%.

A.2.4 San Francisco, California (96)

The *Climate Action Plan for San Francisco* has one of the most ambitious short-term greenhouse gas reduction targets at 20% below 1990 levels by 2012. Transportation is one of the four action categories in the plan since it alone accounts for 50% of total

emissions. There are six transportation strategies to reduce emissions, each with existing and proposed actions. The strategies are:

1. “Increase the Use of Public Transit as an Alternative to Driving”

- *Existing Actions:* San Francisco Municipal Railway (MUNI), Bay Area Rapid Transit (BART), “Transit First Policy,” “Downtown Transportation Impact Fee,” transit oriented development
- *Proposed Actions:* “expand local transit service,” “increase funding for major local service improvements,” “expand and improve regional service and connections,” “develop regional pass system,” “improve safety,” “customer service and user-friendliness of MUNI,” “implement ‘Smart Bus’ technology,” “increase marketing and promotion of public transit,” “expand transportation impact fee assessment,” “create a free tourist shuttle system”

2. “Increase the Use of Ridesharing as an Alternative to Single Occupancy Driving”

- *Existing Actions:* online ride-matching service, “Casual Carpool” system, HOV lanes, temporary waived parking fees for vanpools
- *Proposed Actions:* “increase the number of miles of HOV lanes,” “expand carpool and vanpool designated parking,” “HOV requirements in new large developments,” “implement school ridesharing program,” “increase marketing and promotion of ridesharing”

3. “Increase Bicycling and Walking as an Alternative to Driving”

- *Existing Actions:* expanding infrastructure, improving safety, can carry bicycles on transit network

- *Proposed Actions:* “continue to increase the number of bicycle lanes, routes, and paths,” “continue to improve safe access and passage on pedestrian walkways,” “improve bicycle access to transit,” “continue to improve and expand bicycle parking facilities,” “increase workplace shower facilities for bicyclists,” “increase marketing and promotion of bicycling”
4. “Support Trip Reduction Through Employer-Based Programs”
- *Existing Actions:* working with businesses to promote alternative transportation, “City CarShare”
 - *Proposed Actions:* “expand employer commute assistance and outreach,” “implement countywide guaranteed ride home program,” “conduct general marketing and promotion of commuter services,” “expand employer transportation management requirements”
5. “Discourage Driving”
- *Existing Actions:* parking fees and tolls, “City CarShare”
 - *Proposed Actions:* “increase the gas tax,” “implement congestion pricing and cordon tolls,” “cap or reduce the number of parking spaces,” “collect parking lot taxes from hotels”
6. “Increase the Use of Clean Air Vehicles and Improve Fleet Efficiency”
- *Existing Actions:* “Healthy Air and Smog Prevention Act,” greening the municipal fleet
 - *Proposed Actions:* “lobby for increased CAFE standards,” “support LEV/ZEV sales mandates in California,” “support state-level development

of greenhouse gas emissions standards,” “implement tiered vehicle registration fees based on vehicle size or emissions,” “introduce tiered parking rates based on vehicle size,” “promote bridge toll and HOV lane waivers for AFVs,” “lobby regional agencies to open grants for private sector uses,” “support efforts to expand City CarShare,” “promote and enforce bus idling traffic code”

A.2.5 Boulder, Colorado (97, 98)

Boulder’s climate plan, the *City of Boulder—Climate Action Plan*, was published in 2006 in response to the City Council’s Kyoto resolution that established a greenhouse gas reduction goal of 7% below 1990 levels as of 2012. From this resolution baseline emission levels were determined, and it was found that transportation accounts for approximately 28% of all emissions. The three main strategies for the transportation portion of the plan include lowering VMT, increase fuel economy, and use less fuels with high carbon intensity. Boulder’s own *Transportation Master Plan* is cited as a heavy influence on the *Climate Action Plan* since many of its objectives reinforce emissions reduction strategies, such as provide more alternatives to the private automobile, decrease single occupancy by 25%, and slow vehicle traffic growth. Existing climate change actions include implementation of the *Transportation Master Plan*, GO Boulder (executes alternative transportation programs), and Eco-Pass (discounts on long-term bus passes). From 1990 to 2003, modal splits in Boulder have begun to change. Single occupant vehicle trips went from 44% to 39% of the pie, while bicycle, walk, and transit have all increased. Long-term recommendations of the plan include:

- “Continue to promote and help expand Boulder CarShare”

- “Work with RTD to implement a TravelSmart social marketing program”
- “Support the adoption of the California LEV II standards”
- “Promote local biodiesel and ethanol market development”
- “Promote the use of hybrid technologies”
- “Continue to lead by example by purchasing green vehicles for city fleet”
- “Support state allocation of federal transportation funding on CMAQ projects”
- “Continue to improve transit, walking, and biking infrastructure”
- “Promote changes in land-use planning for long term benefits”

The plan is currently funded by the Trash Tax, but longer-term strategies are being investigated. Even still, not all transportation strategies and recommendations laid out in the plan funded or have identified funding. Only strategies directly related to the *Transportation Master Plan* currently receive funding. Because of the monetary shortfall, raising awareness of the issues and educating the public is seen as an appropriate strategy to combat climate change.

Yearly progress reports related to climate and energy issues are published by the City Council, and the most recent 2006 report showed a decrease in transportation emissions of 2.4% between 2004 and 2005 due to growing use of ethanol and biodiesel.

A.2.6 Denver, Colorado (68)

The *City of Denver Climate Action Plan* was recently published in October 2007, and has an official per capita greenhouse gas reduction goal of 10% below 1990 levels by 2012, but recommends a reduction of 25% by 2020. Currently the plan is a proposal to the mayor and is awaiting adoption. As of 2005, transportation accounts for 38% of Denver’s total greenhouse gas output (31% gasoline and diesel and 7% jet fuel). 5 of the

10 main recommendations of the plan directly related to transportation, such as community outreach/education campaigns, voluntary travel offset fees to support climate programs, leading through updated city operations including municipal fleet, transit oriented development around stations encouraged by growth boundary, and “city support for alternative transportation strategies.” For each recommendation, costs per metric ton of CO₂ equivalent are calculated as well as each percentage contribution towards reaching the 2012 goal. These calculations provide an insightful look into each recommendation’s effectiveness in terms of dollars.

A.2.7 Boston, Massachusetts (44, 99)

In response to Mayor Menino’s climate change executive order in April 2007, the City of Boston has developed its initial climate action plan, titled *Climate: Change*. As an interim measure, the plan adopted the U.S. Mayors Climate Protection Agreement’s reduction goal of 7% below 1990 levels by 2010, but the long-term reduction goal stands at 80% below 1990 levels by 2050. VMT reduction, which is elaborated in another plan, titled *Access Boston 2000-2010*, and alternative fuels constitute the brunt of the transportation principles for Boston’s climate plan. Strategies or actions by the City government include modernizing the municipal fleet to include hybrids or other energy efficient vehicles, large scale transportation projects such as the Central Artery/Tunnel (Big Dig) and the Massachusetts Bay Transportation Authority expansions, transportation access plan agreements in coordination with the Boston Transportation Department that help implement TDM procedures, parking restrictions and policies, encouraging cycling and walking through infrastructure improvements, idling restrictions, and pollution control devices used on public school buses.

A.2.8 Cambridge, Massachusetts (100)

Towards the end of 2002, Cambridge published its first climate change document, titled *City of Cambridge Climate Protection Plan*, that proposed a reduction of greenhouse gas emissions of 20% below 1990 levels by 2010. The overarching principle for the transportation portion of the plan is to focus on strategies that get people out of single occupant vehicles. Two main strategies espoused by the plan are to lower travel demand and lower tailpipe emissions. More specifically, several transportation-related strategies are mentioned, and include:

- “Reduce SOV commuting
- Improve facilities for walking and cycling
- Reduce motor vehicle travel with promotion and education programs
- Reduce motor vehicle emissions
- Promote Transit Improvements
- Use zoning and incentives to foster mixed-used, transit-oriented development
- Work for transit-oriented regional land use planning”

For each strategy, the plan explains past supportive actions, as of 2001, and proposed actions, but there are too many to list and discuss in this summary format.

Broad implementation strategies are also included in this plan, and involve:

- “Provide City leadership
- Undertake a citywide campaign.
- Build on Existing Efforts
- Monitor Progress.
- Establish a Coordinating Committee”

A.2.9 Minneapolis, Minnesota (101, 102)

Minneapolis' *2007 Sustainability Report* includes a portion focused on global warming, and reveals the citywide greenhouse gas reduction goal of 12% by 2012 and 20% by 2020. However, the baseline year for these reductions is not mentioned.

Transportation-related actions taken by the City include a hybrid vehicle car-sharing program, require taxis to become more fuel efficient, allowing right-turn-on-red at certain intersections, expanding bicycle infrastructure, bus and light rail investment, rezoning in downtown area around light rail, and encouraged the legislator to support "the North Star Commuter Rail Corridor connecting northern suburbs with downtown, the Central Corridor Light Rail Transit connecting Minneapolis and Saint Paul, the Interstate 35W and Cedar Avenue Bus Rapid Transit facilities, and dedicated funding for transit."

An earlier voluntary plan to reduce CO₂ was published in 1993 by the City Councils of Minneapolis and Saint Paul, titled *Minneapolis – Saint Paul Urban CO₂ Project Plan: A Framework for Developing Strategies to Reduce CO₂ Emissions, Save Taxes, and Save Resources*. Because this plan is 15 years old, its emissions reduction target year has come and gone. The plan called for a reduction of greenhouse gases of 20% below 1988 levels by 2005. At this point and time the plan is considered out of date, but its strategies, at least relating to transportation, are similar to what is currently occurring in newer climate change plans.

A.2.10 New York City, New York (66)

New York City approved its sustainable city strategy, *PlaNYC*, in April 2007. The plan focuses on six key areas, one of which is climate change, and hopes to reduce greenhouse gas emissions 30% below 2005 levels by 2030. Per capita, New York City

emits the lowest amount of greenhouse gases in the country due to dense neighborhoods, walkability, robust transit service, and high-rise apartments. In essence, “growing New York is, itself, a climate change strategy,” but the City and its government do not intend to rest on their laurels. Sustainable transportation is one of the four components of the climate change plan, with specific objectives including increased transit ridership and decreased automobile usage, improvement of automobile efficiency (including taxis and “black cars”), and lowering the carbon content of fuel. The City also plans to create a climate change adaptation planning process and a task force to protect infrastructure, including transit and roadways.

Other transportation objectives in the plan that may have potential impacts on climate change involve congestion pricing in Manhattan, expanding transit, bringing existing transit into a state of good repair, encouraging cycling, and encouraging transit-oriented development. Implementation strategies consist of focusing capacity improvements on the most congested areas (including commuter rail service into Manhattan), incorporating the underserved into future transit expansion decisions, finishing the bike plan, investigating high occupancy truck-only toll lanes (TOT lanes), and developing “a new regional transit financing authority.”

A.2.11 Portland, Oregon (103, 104)

Portland is considered the pioneer in addressing climate change in the United States because in 1993 it created the first formal plan to address the issue. Eight years later, Portland and Multnomah County jointly developed an updated plan titled *Local Action Plan on Global Warming*. The most recent reduction goal for the City and County is 10% below 1990 levels by 2010, which is acknowledged as a difficult due to rapidly

increasing population in the Portland area. Transportation is identified as the area where the largest share of greenhouse gas reductions will originate and, in total, account for approximately 1.35 million metric tons. The plan states that “transportation reductions will be achieved by reducing per capita vehicle miles traveled to 10 percent below 1995 levels by 2010 and by improving the average fuel efficiency of vehicles in Multnomah County from 18.5 to 26 mpg.” Four transportation principles are identified to achieve emissions reductions:

1. “Reduce the need for trips by using telecommunications and remote access whenever possible
2. Encourage people who must travel to do so on foot, by bicycle, on transit, or as part of a rideshare
3. Implement mechanisms to ensure that people who drive pay the full social cost of driving
4. Improve access to alternative-fuel and highly fuel-efficient vehicles”

Additionally, four central transportation objectives, each with numerous recommended actions for both government and the community, are distinguished and provided below. With these recommendations, meeting Oregon’s “State Transportation Planning Rule requirement of a 10 percent per capita reduction in VMT from 1995 levels by 2015” may be obtainable within the Portland region.

1. “Improve the quality, convenience, affordability, and awareness of walking, bicycling, teleworking, public transit, ridesharing, and vehicle sharing
2. Make the private cost of driving reflect the full costs to society

3. Increase the use of highly fuel-efficient and alternative-fuel engines in on-road and off-road vehicles as well as in stationary applications
4. Change the pattern of urban development to be more compact, more bicycle and pedestrian friendly, to provide for mixed uses, and to offer a range of mobility choices”

Since a progress report is required every two years, accountability is a major component of the action plan. The most recent update was in 2005, and shows that transportation-related greenhouse gas emissions still account for roughly 40% of all emissions. However, the City is quick to point out that it is clearly making steps in the right direction, such as continually developing its light rail and streetcar network, increasing mode share for walking and cycling by 10% between 1990 and 2000 while slightly reducing those driving alone, introducing alternative fuel vehicles into the city fleet, and managing growth in the long term through urban boundaries. Even still, “achieving the 2010 target of 10% below 1990 levels remains an ambitious goal.”

A.2.12 Seattle, Washington (105, 106)

Like other municipal climate plans, *Seattle, a Climate of Change: Meeting the Kyoto Challenge* intends to reduce greenhouse gas emissions 7% below 1990 levels by 2012. The plan was adopted in 2006 and focuses on five themes, two of which in terms of transportation: “reduce Seattle dependence on cars” and “increase fuel efficiency and use of biofuels.” Together these strategies account for slightly more than half of the targeted greenhouse gas reduction. Specific actions relating to these themes include:

- “Significantly” expand public transportation
- “Significantly” expand bicycle/pedestrian facilities

- Investigate regional road pricing with other regional and state agencies
- Raise transit funding through parking tax
- Encourage high density, thereby warranting “more frequent and cost effective” public transportation
- Further fuel efficiency through driver education and encouragement of greener fleets, among other strategies
- “Substantially” more biofuels
- “Significantly reduce emissions from diesel trucks, trains and ships”

According to the *2007-2008 Seattle Climate Action Plan Progress Report*, much progress has been made in the Seattle area. Specifically, the progress report cites the new South Lake Union Streetcar, the Sound Transit Light Rail line from downtown to the airport, expanded bus service, new bicycle and pedestrian facilities, continued greening of the municipal fleet, and the City’s research into electricity to help power transportation. As of 2005, greenhouse gas emissions were down 8% from 1990 levels, but transportation emissions are still increasing. In terms of climate change, the City views transportation emissions reductions as its “toughest challenge.”

A.2.13 Madison, Wisconsin (107)

The City of Madison has not updated its *Climate Protection Plan* since January, 2002, and, admittedly, has not put much of the plan’s focus on transportation-related issues as much as the energy sector. Nevertheless, at the time of the plan’s drafting, transportation accounted for 17% of all greenhouse gas emissions, which provided the City enough incentive to offer several transportation-related recommendations to help achieve the initial community-wide reduction goal of 7% below 1990 levels by 2010.

Recommended actions include replacing all traffic signals with light-emitting diode bulbs, encouraging purchase of alternative fuel vehicles for city fleet, training fleet drivers to drive more efficiently, beginning testing of alternative fuel bus, studying feasibility of rail transit service, examining parking policy “to ensure they are not unintentionally encouraging automobile use,” and expanding bicycle infrastructure. The plan also highlights several characteristics of Madison that provide distinct posturing in tackling climate change, such as the City’s high rate of bicycle usage (“3:2 ratio of bicycles to cars”) and the pedestrian/transit mall along State Street.

A.3 International Cities

A.3.1 Brisbane, Australia (59, 108, 109)

Within the past few years the Brisbane City Council (BCC) created an independent body, Climate Change and Energy Taskforce, to investigate the effects of greenhouse gas emissions and peak oil on the City. The Taskforce recently released a report, titled *A Call for Action*, that includes non-binding recommendations for the BCC to consider. One of the overarching recommendations for the BCC is to create specific emissions and oil consumption reduction targets. Some recommendations specifically related to transportation include a higher degree of involvement (“direct investment and regulatory intervention”) in fostering and developing transit-oriented developments, raise investment in public transit (more bus priority lanes, future bridges include light rail lanes, and connect key areas currently not serviced), influence alternative transportation choices such as walking and cycling, perform a future study focused on long-range planning to reduce oil consumption and emissions, implement travel demand strategies (increasing cost of personal transport and attempting to spread peak commute hours more

evenly), utilize alternative fuels (even in the freight sector), and “change practices and specifications for the siting, design and maintenance of transport infrastructure to incorporate the implications of climate change.” The BCC’s *Draft Transport Plan* reaffirms some of these recommendations by mentioned travel demand management and alternative fuels as primary methods of reducing greenhouse emissions.

The *Integrated Regional Transport Plan for South East Queensland* has a bold target of reducing vehicle trips by 19% by 2011 (roughly 5.9 daily vehicle trips). The plan intends to realize this target through travel demand strategies, land-use planning, and promoting public transport, walking, and cycling. Oddly enough, the plan essentially states that land-use planning will not work because “the region’s population is currently reluctant to change lifestyle and location decisions.” And even though 78% of Brisbane is concerned with air pollution, there is a “reluctance to consider initiatives which restrict private vehicle use.” Even though this is the most up-to-date regional transport plan for South East Queensland, it appears outdated. There is no date on the plan or the webpage to suggest this, but a sentence in the plan gives a big clue: “by 2005, it is estimated that 10% of all new vehicles will be electric vehicles requiring charging of energy storage devices.” There is a newer action plan document from 2001 that is meant to follow up on the plan, but it is not available to download.

A.3.2 Melbourne, Australia (31, 110, 111)

The Victoria government published a long-range plan for the City of Melbourne, titled *Melbourne 2030: Planning for Sustainable Growth*. The plan covers a variety of topics, including transportation, and recognizes key linkages that affect one another. For example, a “key direction” in the plan is to establish an urban growth boundary to

simultaneously plan land use in a smarter fashion and “produce an urban form that can be serviced efficiently so that public transport services are provided concurrent with development.” The plan asserts the current transport network favors automobiles and not public transport (though Melbourne has the 3rd largest streetcar network in the world), and that an equitable balance of incentives must be in place in order to increase transit’s share of trips to 20% (from 9%) by 2020. Cycling and walking is addressed as a means of reducing car travel, and the government hopes to have 30% of all freight on rail by 2010. The plan includes a strategy on incorporating sustainability into the decision-making process as well. A climate change program is also maintained by the Victoria government, and it consists of over 100 initiatives (not all of which transportation-related).

A major goal of the Melbourne transport strategy, *Moving People and Freight*, is to have most additional trips to the city conducted via public transportation by 2020 in order to allow for utility services that must use the roadway network—like freight (which is a major economic engine for the City). “Dynamically managing” parking, both on-street and short term, is an interesting priority in Melbourne (the city has 65,000 parking spaces—more than any other Australian city). Car sharing (similar to Zipcar) is promoted in dense neighborhoods with restrictive on-street parking supplies. The City does not recognize buses as sustainable commuting options. Bus purpose is to feed into large rail and tram network. Also, the City “Council recommends Federal and Victorian governments review taxation and charging policies, including fringe benefit tax, which distort the real costs of car driving and undermine the development of attractive salary packages that include subsidised public transport for workers.” The City has long-term

greenhouse gas emission targets to reduce emissions to levels during 1996. Price and availability of oil is identified as a large freight risk, subsequently encouraging the City to promote rail as the preferred mode choice for freight. “Empty running or partial loading to and from the port of Melbourne” by trucks is discouraged to reduce overall number of freight trips. Overall, Melbourne’s main sustainability strategy is to intensely promote alternative modes that already exist or will exist.

A.3.3 Sydney, Australia (112, 113, 114)

The metropolitan plan for Sydney, titled *City of Cities: A Plan for Sydney’s Future*, was published by the New South Wales Government in 2005. Sustainability is used to frame some of the transportation strategies, instead of climate change, but the principle of reducing greenhouse gas emissions remains. The three sustainable strategies of the plan include: improving cycling and walking networks for short trips, creating a “metropolitan parking policy,” and promoting voluntary behavioral changes in an educational campaign known as “TravelSmart.” The goal for the parking policy is to promote the use of public transportation in select corridors by restricting or pricing parking where adequately served by transit (integrated land use and transport planning for corridors and centers of activity is the favored approach by the metropolitan plan).

Another plan by the New South Wales government is called the *NSW Greenhouse Plan 2005* and discusses current and future strategies for reducing greenhouse gas emissions across many activities, including transportation. The overall plan is divided into three sections: awareness, adapting to environmental changes, and emissions reduction (most of the plan is concerned with this). Specific transportations strategies include alternative fuels, incorporating climate change into freight planning, supporting

new emissions standards, and raise awareness of the issue to local governments. Some actions already implemented in the area include transport reforms such as an overhaul of the bus network to provide more frequent service and a new rail program called Rail Clearways Program that is “untangling” lines in the suburbs to increase passenger capacity. Changing the “Fringe Benefits Tax system,” which encourages private companies to provide automobiles as part of salary, remains an ongoing process.

The City of Sydney is also conducting its own sustainability plan, *Sustainable Sydney 2030*. The plan is still being developed, but information on the direction in which the transportation portion of the plan is taking is available online. Climate change and greenhouse gas emissions are already listed as a major priority for the plan, and getting people out of their cars is one of the main overarching principles. The plan will create both regional and local objectives as well.

A.3.4 Vienna, Austria (115)

With the language barrier present, it is hard to really grasp the totality of the *Transport Master Plan Vienna 2003 (Mobil in Wien)*. An abridged English version is available but the grammar is difficult to follow at times. Nevertheless, climate change information is within the plan. Incorporating “true costs,” which includes climate change, into the planning process is a major goal for the plan. The plan also calls for an upper limit on non-residential parking spaces in the city, “a fee-based car park management system,” and an examination of a “tax on traffic-generating elements.” Road pricing is present in Vienna and the plan suggests 29 cents per kilometer as the rate. “The short-stay parking rates and consumption taxes, unchanged since 1986, should be reviewed, and the award of grants for residential development should depend on areas

with good public transport connections.” Most of the solutions in plan are placing constraints on private automobile use. Vienna also wants to reduce CO₂ emissions by 5% per capita by 2010.

Apparently there is more to the planning puzzle in Vienna. The plan mentions cooperation in the planning process with local municipalities and the regional authority, both of which could not be found for this research. Vienna is also a state in Austria, but is surrounded by the state known as Lower Austria. Searching for this regional authority, both in English and German, returned no recognizable results.

A.3.5 Brussels, Belgium (116, 117, 118)

The Environment and Energy of the Brussels-Capital Region, known as Bruxelles Environment-IBGE, has its own climate strategy, *Plan for Structural Improvement of the Air Quality and the Fight Against Global Warming* (approximate translation). The plan pinpoints developed countries as the primary source of the greenhouse problem and states that a reshaping of the way we live, including how we use transportation, is necessary to combat climate change. Recommendations in this plan serve to supplement the *Mobility Plan IRIS* for the Brussels-Capital Region, which, as of writing the climate plan, only had a stated goal of stabilizing vehicle travel by 2005. Policies from the climate plan that are being looked into include increasing “market share of two-wheelers,” reinvesting in pedestrian walkways, promoting car-sharing and clean vehicles, and funding public transportation to increase availability throughout the region. Other policies being looked into would potentially increase the rail mode share for freight and attempt to plan employment centers in a manner that would reduce sprawl and the need to travel. Specific objectives of the plan include:

1. Controlling demand for private automobile use through both regional and district parking policies that favors cyclists, pedestrians, and transit. “The duration of parking will be limited by the application of a progressive pricing policy.”
Parking regulations make up the majority of transportation-related recommendations.
2. Mandatory parking management programs for businesses with over 200 employees
3. Developing a regional policy based on promoting behavioral changes in travel (essentially educating people on why they should drive less)
4. Adopt a blueprint for increased bicycle and pedestrian connectivity, as well as proper way finding signs
5. Discourage short-term parking near train stations in the outer fringes of town
6. Set an example by introducing clean vehicles into the municipal fleet and create a clean vehicle education campaign
7. Support the federal government in any regulation that would control emissions
8. Create an “eco tax” cooperatively with neighboring regions that would discourage the use of the most polluting vehicles, “provided that the measures taken do not endanger the economic and financial balance of the Regions.”
9. Include clean vehicles as part of the requirements to bid for taxi licenses
10. Look into managing the entrance and exit of vehicles into and out of the City
11. Mandatory non-use of vehicles on days of severe pollution
12. Public information campaigns concerning the greenhouse gas problem and the benefits of using public transportation

The *Mobility Plan IRIS* is being updated, and mentions that the business as usual approach to transportation planning would result in a 22% more CO₂ emissions. To help minimize this increase, the plan recommends:

1. “Major investments in infrastructure: metro extension
2. Major investments in infrastructure: development of the suburban train network
3. Development of the limitation to 30km/h in residential areas
4. Exclusive right of way for surface public transport
5. Road pricing: charge when crossing the ring or related to the distance traveled
6. Parking policy
7. improvement of security and parking possibilities for cyclists
8. Road space dedicated to public transport, pedestrians and cyclists
9. Free public transport
10. Development of evening and night services”

The Brussels-Capital Region is working on cooperation with the European Union on the project *European Scenarios on Transport-Energy-Environment for Metropolitan Areas* “to adjust and validate integrated models of the interactions between land-use, transport and environment.” The project is looking into road pricing in the Brussels, as well as introducing commuter lines from the suburbs to the city.

A.3.6 Curitiba, Brazil (119, 120)

Curitiba is arguably one of the most famous examples of successful public transportation in the world, and has been a pioneer in bus rapid transit (BRT) implementation since 1974. The city only uses buses for public transportation, but the BRT system is well-developed and serves to the same capacity of more expensive rail

systems. Pedestrian-only areas in the city center “act as feeder services to the BRT system by easing pedestrian movements towards stations.” High-density land uses are zoned alongside BRT lines, as well, and one can basically tell where lines exist by looking at current online satellite images. The current mayor of Curitiba, Beto Richa, highlighted his city’s integrated transportation and supportive land use at the *C40 Large Cities Climate Summit* last year as an example of how to combat global climate change. It can be argued, however, that such an integrated transportation system may be difficult to implement in other regions that lack “highly charismatic mayors.”

A.3.7 Montreal, Canada (121)

The title of the vision and objectives portion of the *Montreal 2007 Transportation Plan* is *a Radical Change of Course*. Montreal stresses that a bold change is needed in transportation to reduce greenhouse gas emission levels in the spirit of the Kyoto Protocol. Initiatives in the plan that will help mitigate climate change include placing pedestrians as the highest priority in planning, further developing efficient transit service to get people out of cars, promote and develop bicycle facilities, encourage more vehicle sharing, manage parking, and emphasize alternative modes in public roadways.

A.3.8 Toronto, Canada (122, 123)

As of right now, the Greater Toronto Transportation Authority, also known as Metrolinx, is creating its first regional transportation plan. Not much information is available at this point, but the first of seven “Green Papers” is accessible on the website. The document, *Towards Sustainable Transportation*, contains language concerning climate change. One of the “three pillars” of the upcoming RTP is the environment. The two components of this pillar are limiting greenhouse gas emissions and “operating

within the constraints of our ecosystem” by favoring low-emission transportation, presumably transit, cycling, and walking. Nothing concrete is provided in this paper. Instead, it discusses current transportation topics and issues that Metrolinx is considering for the RTP development.

Climate Change, Clean Air and Sustainable Energy Action Plan: Moving from Framework to Action, or more simply *Change is in the Air*, is a climate change plan drafted by the City of Toronto, with the first phase published in 2007. The plan establishes greenhouse gas targets below 1990 levels for 2012 (6%), 2020 (30%), and 2050 (80%). The recommendations for action for transportation include conducting implementation studies for the Transit City plan as well as the Bike Plan, developing a Sustainable Transportation Implementation Strategy that gathers information from other City transportation plans, creating a Strategic Transportation Planning Group to oversee implementation, moving all taxis and limousines to hybrid vehicles, investigating road pricing, and encouraging other governments (federal and provincial) to plan with greenhouse reduction targets in mind. Toronto is currently drafting a report adapting to concerning climate change that is due soon.

A.3.9 Vancouver, Canada (124, 125)

Several years ago Metro Vancouver, an amalgam of four separate governmental agencies, updated its *Air Quality Management Plan* to include the minimization of contributions to climate change as one of its three main goals. The recommendations in the report mostly rely on promoting cleaner vehicles and fuels to reduce emissions, and nothing is discussed in the context of planning.

The *2007 Transportation Plan* by TransLink investigates climate change through transportation via the Urban Transportation Showcase Program, a federal program funded by Transport Canada. The program is open to the entire country and is designed to fund “showcase” projects that may minimize the effects of or mitigate climate change through a reduction in greenhouse gas emissions. Metro Vancouver was approved for six distinct projects: TravelSmart (similar to Sydney’s program), SkyTrain’s “Transit Villages,” “Central Valley Greenway Regional Bicycle and Pedestrian Commuter Path,” alternative fuel demonstration for buses (four fuel types used), transit priority on Main Street, and a goods movement strategy.

A.3.10 London, England (60, 64, 126, 127, 128)

In the *Transport 2025* document, Ken Livingstone, former mayor of London, declares climate change as “the single biggest challenge we face” in terms of the environment. The plan mentions that a reduction in congestion by continuing the recent modal share increases in public transportation, as well as cycling and walking, is the key strategy for reducing CO₂. Peter Hendy, commissioner of Transport for London, mentions the measures to reduce CO₂ “includes enhanced public transport capacity, smart transport measures, a Climate Change Action Plan, technological improvements in the vehicle fleet, and the implementation of a national road user charging scheme in London.” The overall goal is to reduce CO₂ emissions to 30% below 1990 levels (50% below 2000 levels) by 2025.

Reducing CO₂ emissions is one of the six main strategies of the plan and one of three main objectives, but there are some identified barriers to realizing this reduction. Managing the road network, in terms of re-allocating road space for public transit and

creating policies to decrease automobile traffic, as well as improving the urban environment, which encourages people to walk or take transit, are seen as major barriers. Increasing or expanding road capacity is not viewed as a viable strategy for congestion relief, which equates to CO₂ relief, because it will allow even more to drive automobiles.

Some of the suggested actions of this plan that would directly help mitigate climate change include public private partnerships increasing efficiency on the London Underground network, expansion of transit capacity, increased automobile efficiency, demand management (land-use planning, strategic parking management, and low transit fares or concessions), various cycling initiatives, and implementing a greater degree of road user charging (RUC). If the vision of the plan is carried through, London expects to see a 22% reduction in CO₂ emissions and “nine per cent mode shift from car to public transport, walking and cycling,” and 30% drop in congestion when compared to the reference case by 2025. The Mayor’s target of CO₂ reduction of 30% can only be met “if supporting legislation to improve the carbon efficiency of new vehicles is forthcoming from national and European government or a greater impact of RUC on the most polluting vehicles is achieved.”

The mayor is directly involved in other plans such as *The Mayor’s Energy Strategy* and the *Mayor’s Climate Change Action Plan*. Most of the policies of these documents echo those found in *Transport 2025*, but some other interesting information is available. For instance, the Mayor is requiring TfL to update its vehicle fleet with clean burning fuel technology such as fuel cells/hydrogen. Every conceivable mode of transport is also given efficiency consideration in *The Mayor’s Energy Strategy*, but

summarizing each one would prove too lengthy. In the *Climate Change Action Plan*, “eco driving” is mentioned as one of the five main strategies.

A.3.11 Helsinki, Finland (129)

The Helsinki Metropolitan Area Council published a document known as *Climate Strategy for Helsinki Metropolitan Area 2030*, but due to language barriers the only English information available is a PowerPoint presentation that does not go into much detail. In spite of this some information is available. The goal for the region is to reduce greenhouse gas emission levels by 1/3 from 2004 levels by 2030. The goal is laudable but not as stringent as other European cities that base their reduction targets on 1990 levels. To help meet this goal the strategy calls for travel demand policies (such as road pricing schemes), incentives to use alternative fuel automobiles (such as by waiving or reducing parking costs), increasing the attractiveness of public transportation through expansion of the existing network and more reliable service, and encouraging more cycling and walking (by expanding the network and providing bicycle parking).

A.3.12 Paris, France (130)

Plan Climat de Paris is the climate change strategy document from the City of Paris. Google Translate was used to translate this all-French document into English. The ultimate goal of the strategy is to reduce greenhouse gas emissions from the Parisian territory by 75% from 2004 levels by 2050. The interim goal for 2020 is to reduce emissions by 30% from 2004 levels. Unfortunately, the translation of the document is quite poor, making the identification of specific strategies very difficult. Additionally, it is difficult to say whether the greenhouse gas reduction targets are for municipal fleets or all of transportation.

A.3.13 Berlin, Germany (131, 132)

Like other European cities, Berlin employs an environmental zone in the city center to prevent heavily polluting vehicles from entering. The zone is meant to curb the emissions of particulate matter and nitrous oxides, not CO₂, but the benefits of climate change minimization are still present. “This restriction applies to less than 7% of the total number of 1.2 million motor vehicles currently registered to Berlin.” After reading the translation of the Berlin *Mobility 2010* document it appears that all planning scenarios resulted in an increase in CO₂ emissions.

A.3.14 Dublin, Ireland (133, 134)

The Dublin Regional Authority does not have a climate change strategy of its own, per say. Instead, their strategy is the *Review of the National Climate Change Strategy*. The document is only several pages long and is quite succinct with its recommendations listed in bullet form. Procedural recommendations for transportation include incorporating policies that support telecommuting, integrating transportation planning for all modes, and marrying overall quality of life with transportation planning. Other recommendations include taxing vehicles based upon pollution per kilometer, the purchasing of energy efficient buses, stopping fare hikes to increase attractiveness of transit, and a “cost benefit analysis as an integral part of the capital programme.”

The *Regional Planning Guidelines* for transportation do not mention climate change or greenhouse gases, but its goal of large investment in public transportation is essentially a mitigation technique. Most of the investment is nothing out of the ordinary and is generally related to new stations and capacity increases, but plans do call for a commuter rail tunnel underneath the city to create a more seamless network.

A.3.15 Rome, Italy (135, 136, 137)

In the City of Rome, Department VII, or the Mobility Department, is in charge of all things transportation. The department has created several “limited traffic zones” (LTZ) in portions of the city to limit access during peak hours. Originally started for the city center during daytime hours, LTZs in other areas and during night hours now exist. The LTZ is only meant to be a tool for congestion relief, but it helps minimize greenhouse gas contributions in the city. Funds from the LTZ go towards transit.

Since 1998, Department VII has had a sustainable mobility program with an overall goal of promoting alternative forms of transportation other than the private automobile. Portions of the program include a mobility manager for businesses to encourage carpooling or other modes of transport that pollute less relative to cars, a taxi collective, promotion of car-sharing, and a monetary incentive program for the purchase of zero-emission vehicles, though funds for this program are currently exhausted.

A.3.16 Tokyo, Japan (138, 139)

It is one of the principle priorities of the Tokyo Metropolitan Government (TMG) to address environmental issues, and reducing greenhouse gas emissions is an objective of this priority. Only two objectives are related to transportation, though: encouraging “eco-driving” techniques and attempting to consolidate deliveries to small shops so that fewer vehicles are used. Last year the TMG passed a 10-year climate change strategy, but like the principle priority of addressing environmental issues, only a few objectives are related to transportation. Eco-driving is again listed as a mitigation technique, as is continual promotion of hybrid vehicles. Finding any concrete information about Tokyo is challenging.

A.3.17 Mexico City, Mexico (140, 141)

After e-mailing Beatriz Del Valle Cárdenas, the lead coordinator for climate change projects in Mexico City, she sent a document highlighting the development of the first climate change plan for the City. The plan should be coming out in 2008. She mentioned that transportation would be one of the six focus areas of the plan. One of the biggest pieces of the plan is the introduction of two clean BRT lines per year for the next five years, for a total of 10 new lines. The lines will eventually total 234 km and “will reduce 369,482 metric tones CO₂ equiv / year.” In conjunction with the World Bank, Mexico City is also working on:

- “Natural Gas and Electric bus testing.
- Non Motorized transport plan.
- Sustainable transport plan.
- Impact analysis of Metrobus projection and total integration with metro.”

Mexico City’s mayor also has revealed the *Plan Verde*, which includes a program where private automobiles cannot be used on certain days, depending on the license plate number. This scheme is similar to Seoul’s car-free days, except that program is completely voluntary. The city also is also trying to replace all of its municipal fleet with clean vehicles.

A.3.18 Amsterdam, Netherlands (142, 143, 144)

The *Regional Traffic and Transportation Plan*, published in 2004 by the Amsterdam regional authority, Stadsregio Amsterdam, understands that transportation is a major emitter of CO₂, which contributes to climate change. However, the plan also says that while the Netherlands is bound by the Kyoto Treaty, there is not a legal standard

for the Amsterdam area. Consequently, “CO₂ reduction is not a core task.” The documents *Public Transport in the Amsterdam Region 2020-2030* and *Regional Public Transport as a Foundation for the Amsterdam Metropolis* (approximate translation), on the other hand, recognize the importance of extending transit into the outer areas of the city as a means of reducing CO₂ emissions and combating climate change. In these documents, expansion of and investment in the transit network is framed in the context of lowering climate change contributions.

The City of Amsterdam’s climate webpage has a document titled *Amsterdam Central City Environment 2008* (approximate translation) that mentions the entire inside portion of the ring road A10 is an emission zone where certain trucks are not allowed. This area equates to the entire city center. Amsterdam is also teaming up with the Clinton Global Initiative to develop a digital service that tells the user the best option for reaching their destination. Free transit as a means of reducing greenhouse gases, as presented in the *Environmental Policy Plan* is being looked into.

A.3.19 Rotterdam, Netherlands (72, 145)

Rotterdam is seeking to become the “world capital of CO₂-free energy” with its *Rotterdam Climate Initiative*, a partnership between various local agencies that seeks to cut CO₂ emissions to 50% below 1990 levels by only 2025—currently the most aggressive CO₂ reduction found during this research. Given the size and importance of the Rotterdam port, it is unsurprising to note that much focus is given to curbing emissions in this area and the industries that support it. Industry will account for approximately 83% of all CO₂ reductions, with the remaining cutbacks in “road and water.” Immediate transportation measures currently in place restrict heavily polluting

trucks from entering the city center, promote heavy bicycle use, provide a fleet of 1,600 clean vehicles, and address shipping pollution in the port. For the long term, Rotterdam plans to meet its greenhouse gas goals “through the use of alternative fuels, engines and radical optimization of traffic behaviour [sic]” and make the transition through “the use of transportation systems and the way mobility fits into the spatial environment.”

Objectives of the long term involve increasing CO₂ regulations, managing parking in city center, expanding the transit network and park and ride facilities, and augmenting “environmental zones” to cut truck use.

The *Regional Agenda of Traffic and Transport Implementation 2007-2011* (approximate translation), authored by the regional authority, Stadsregio Rotterdam, officially supports the *Rotterdam Climate Initiative* and acknowledges that climate change is a growing concern. The agenda says it will work towards sustainable mobility practices through three distinct efforts (direct translation):

1. Clean and more climate neutral fuels (natural gas, biofuels, hydrogen)
2. Clean and efficient vehicles (hybrid electric drive, fuel cells, weight, exhaust treatment)

More efficient use (transport management, traffic management, intelligent traffic systems, pricing policies, promoting alternatives of cars, etc)

A.3.20 Auckland, New Zealand (146)

The *Auckland Transport Plan*, published by the Auckland Regional Transport Authority (ARTA), identifies increasing greenhouse gases as a trend in transportation. Although primarily framed in an environmental justice context, “reducing reliance on

private cars” is a key transportation issue in the plan that can have impacts on climate change. Lessening environmental sustainability as a result of non-renewable resources is a key issue as well. Not much is mentioned in this plan concerning climate change or greenhouse gas emissions, except for one objective. Objective 5 seeks to reduce greenhouse gas emissions by funding projects that may reduce congestion and promoting “alternatives to private vehicle use.” However, CO₂ emissions are estimated to rise by 21% by 2016.

The ARTA also published a *Sustainable Transport Plan* that includes a walking and cycling action plan. Climate change and greenhouse gases are not specifically mentioned, but the recommendations are essentially the same. Increasing accessibility to transit and promoting other modes are the top priorities in this plan. Land use guidelines to help facilitate these priorities are presented in this plan as well.

A.3.21 Wellington, New Zealand (147, 148)

Climate change is one of the defined transport issues of Greater Wellington Regional Council’s (GWRC) *Wellington Regional Land Transport Strategy 2007-2016*. The strategy mentions both lessening greenhouse gas emissions and adaptation of the transportation network to climate change. One of the six main objectives of the strategy is to “ensure environmental sustainability.” Specifically mentioned in this objective:

1. “Increased use of passenger transport, cycling and walking
2. Reduced use of private and company cars
3. Increased energy efficiency of the vehicle fleet
4. Reduced greenhouse gas emissions
5. High standard of environmental design of transport infrastructure”

Policies listed in the strategy that may potentially have positive impacts on climate change include: travel demand management (reduce automobile dependency, possible road pricing, and integration of land use and transportation planning), general environmental considerations that take into account a reduction of greenhouse gas emissions, and integrated planning where transportation planning is considered in other planning efforts. The Council also created a separate document, *Regional Travel Demand Management Plan*, that goes into more detail how the area can manage its automobile travel and, consequently, its emissions levels. A webpage summarizing climate change appears on the GWRC's site and reaffirms the objectives and policies discussed in the transport strategy.

A.3.22 Oslo, Norway (149, 150, 151)

The City of Oslo has one of the lowest outputs of greenhouse gas per capita in all of Europe, but the City is still concerned about its role in “unavoidable” climate change. *Reducing Greenhouse Gas Emissions and Improving Air Quality in Oslo* is the City's official response to the situation. Oslo is embracing tough greenhouse gas reduction targets, with a goal of 50% reduction from 1990 levels by 2030. Some adopted measures include cooperating with neighboring municipalities to continue to promote densification and the expansion of the transit network, expanding the toll network inside the city, promote mobility planning for businesses, embracing new technology to make freight more efficient, encouraging the use of low impact vehicles, using cleaner and alternative fuels, teaching “eco driving” techniques, and reducing speed limits on certain highways. The funding needed for these climate change mitigation efforts is estimated at €50 million annually.

The *Climate and Energy Action Programme for the Oslo Region* presentation highlights some reasons why Oslo has been so successful so far. The toll ring road currently reduces city traffic by 5-10% and finances other transportation projects that reduce greenhouse gas emissions, such as tunnels below the city for through traffic and public transit improvements. Oslo also published *Strategy for Sustainable Development* in 2002. This document is a few years older than the air quality guide and essentially suggests the same goals and objectives. However, it is interesting that the City's official stance, according to this document, is that "the greatest number of journeys possible shall be made on foot or bicycle."

A.3.23 Edinburgh, Scotland (152, 153)

SEStran, or the South East of Scotland Transport Partnership, published its most up-to-date transport strategy, titled *Regional Transport Strategy 2008-2023*, in 2007. The strategy recognizes climate change as one of its key issues, stating that "the most car-dependent economies are likely to be hardest hit by any increase [in the cost of operating an automobile]." Creating a region less dependent on automobiles through investment in transit, bicycle and pedestrian facilities is a clearly stated objective of the plan. Reducing greenhouse gas emissions by 60% below 1990 levels by 2050 is the overall climate change goal for the region.

Policies outlined in the strategy show a preference for bus as the primary mode of public transportation by giving it favored treatment for future planning in order to lessen automobile dependence. Rail is favored for investment as well but buses are still recognized as the primary mode for city travel. Traditional expansion of the roadway system as a means of addressing congestion is not entirely present; instead the strategy

has a policy that congestion should be mitigated through modal shift and demand management. New roadways can still be created through, provided it can be shown that it will not incite latent demand “and that other alternatives have been evaluated and found to be less effective.” As with most other metropolitan areas, shifting freight travel to rail and water passages is encouraged. Policy also states that access to transit, bikes and walkways as well as proximity to services should be considered with new development, and that planning agencies may use their power to see this through. Additionally, modes that are not dependent on non-renewable resources will receive priority for realization.

Local Transport Strategy 2007-2011, published by the City of Edinburgh, is also planning with climate change in mind. A policy of the strategy states that “the Council will take full account of potential climate change impacts and emissions targets in developing future transport proposals.” Two objectives of the strategy coincide with this policy: strengthen the modal share of bicycles, pedestrians and transit users, and lowering the need to travel at all.

A.3.24 Seoul, South Korea (154, 155, 156)

In 2003, Seoul’s Traffic Policy Division implemented a plan for car-free days within the city to encourage people to use alternative modes of transportation. The program is voluntary, but awards benefits to those that sign up, such as discounts on fuel, parking, and congestion charges. To make the biggest possible impact, the car-free program is for weekdays only. So far the program has reduced CO₂ vehicles emissions by almost 10% annually. Seoul is taking its car-free stance seriously. The city is tearing down an elevated highway to restore Cheonggyecheon, a river in which the highway was built over, and plans call for BRT by the new riverfront. *Seoul, a Clean and Attractive*

Global City, a plan by the City Administration, mentions an increase of bus-only lanes from 7 to 12. Seoul also had a lofty target of reducing private car transport by 50% by 2005, but a follow up study to confirm if this goal has been met could not be found.

A.3.25 Stockholm, Sweden (157, 158, 159, 160)

The City of Stockholm has a greenhouse gas publication titled *Stockholm's Action Programme Against Greenhouse Gas Emissions*. The objective of the plan is to reduce greenhouse gas emissions to 60-80% of the year 2000 level of 4.5 tons per inhabitant. Emissions levels actually dropped 4% from 1990 to 2000 even with an 11% population increase, but forecasts generally see per capita rates rising. Ongoing efforts related to transportation include Hammarby Sjöstad (very large transit-oriented development containing 8,000 new dwellings), gasoline infused with 5% ethanol, diesel with 2-5% biofuel, a Road Information Centre [sic] with a goal of traffic calming, the Årsta bridge (increasing commuter rail line capacity by 4 trains per hour), car sharing program, more stringent speed limit compliance, promotion of cycling, eco-driving education campaign, and buses equipped with fuel cells. Planned efforts related to transportation include increasing green energy purchased by the City (which could be used for transit), increasing the number of "filling stations" for clean vehicles, ferries and heavy vehicles powered by biogas, more park and ride lots, and a 7% increase in transit market share. Conceivable measures related to transportation include promoting fuel efficient cars, purchase renewable fuel or electric buses, increase smart card support, lowering speed limits within and outside of the City, and raising ethanol content in gasoline from 5% to 15%.

The *Regional Development Plan*, adopted in 2002, does not frame transportation objectives within climate change. However, some of its recommendations are in line with a reduction of greenhouse gas emissions, such as increasing commuter rail capacity, increasing express-bus service, and creating “high-quality transfer points.” Much like London, Stockholm has its own congestion charging system for entering and exiting the city center. The charge is referred to as a “congestion tax” and the cost to the driver varies by time of day. Additionally, the tax is not imposed on holidays, the day before holidays, weekends, and the entirety of July. Once strictly considered a trial period in the first half of 2006, the tax is now permanent as of August 2007. Revenues from the tax go to fund new road construction throughout the region. However, revenues were initially funding public transportation during the trial period. The purpose of the tax, according to the City, is to improve the environment and lessen congestion. In fact, traffic volumes during the trial period “fell by an average of just over 20 percent.”

Stockholm also started a clean vehicles program in the late 1990s, which applies to the City fleet and general automobiles. The program aims to grow the market share for cleaner automobiles, which stands around 1% (as of 2003) of all vehicles and more than 50% of the City fleet. The plan’s overall strategy is to educate citizens about clean vehicles, work with oil companies to build infrastructure and charging stations, offer “carrots” (free parking or no toll) and tax breaks to keep costs down, and form groups to consolidate demand to keep purchase prices to a minimum. Businesses can reduce up to 20% of their transportation and environmental costs by participating in the City’s smart card program. The smart card is not only connected to public transit, but also to an alternative fuel car-sharing network. Clean vehicles may be reserved online using the

card, or online services “can help you choose the most suitable ways to reach your destination.” The card allows for all modes of transport to be paid by one convenient method.

A.3.26 Geneva, Switzerland (161, 162)

The State of Geneva holds an “eco-driving” class based on the same techniques in other cities. Enrollment for the class has reached 45,000 total participants, and studies have shown the techniques to be 10% more efficient than normal driving. The State enrolls many of its employees in this program as well to set a good example (1,300 participants in total). Due to the rough translation it is unclear by what means parking is managed in the City of Geneva, but there are parking policies in place to encourage usage of other transport modes. Public transportation received a “massive” expansion between 2003 and 2006. The growth rate for expansion is 20%. Biking and walking are also heavily encouraged in Geneva.

By 2020, motorized transport in Geneva is expected to increase by 40% from 2000 levels, according to the City’s mobility plan. The plan is for businesses and organizations to encourage their employees to get out of automobiles and into other modes of transportation. Some measures adopted in the plan include parking charges used to lower the price of transit tickets by 40%, bicycles and related equipment available to employees, and car-sharing. Results of the plan showed that 10% of employees gave up their parking and roughly “60 parking spaces were eliminated, permitting a new use of spaces.” In total, 7.6% of employees made the switch to public transportation.

A.3.27 Zurich, Switzerland (163, 164)

The total transportation concept of the Canton of Zurich does not mention climate change, but it does discuss strategies for improving the environment through sustainable transportation measures. The concept stresses foot and bicycle traffic, moving freight traffic onto rail lines, and continued investment in public transport to maintain current high modal share. In the sustainability plan by the City of Zurich, approximately translated to *Sustainable City Zurich – On the Way to 2000 Watt Society (Nachhaltige Stadt Zürich - auf dem Weg zur 2000 Watt-Gesellschaft)*, road pricing is mentioned as a topic for further investigation to lower traffic volumes of personal automobiles.

APPENDIX B

E-MAIL CORRESPONDENCE

B.1. David Jackson, Atlanta Regional Commission

B.1.1 Original E-mail

From: Nicholas Schmidt
Sent: Thursday, May 29, 2008 3:35 PM
To: David Jackson
Subject: Greenhouse gas modeling

Hello Mr. Jackson,

My name is Nick Schmidt and I am a graduate student at Georgia Tech. I am currently finishing up my thesis on transportation planning and climate change, but I would like to include the analysis of ARC's greenhouse gas modeling. I have attached the results of the analysis, which I received from Dr. Meyer. I was instructed by Dr. Meyer to message you regarding these results. I guess I was wondering if you could provide some sort of summary, if you have time, about the process of obtaining these results. Without any sort of explanation or presenter, it's difficult for me to figure out the process with just the presentation. I would really appreciate this if you have a moment. Thank you and have a great day.

-Nick Schmidt

B.1.2 Response E-mail

Date: Mon, 2 Jun 2008 10:26:28
From: David Jackson
To: Nicholas Schmidt
Subject: RE: Greenhouse gas modeling

Okay Nick,

So what we did is use Mobile6 to estimate emission factors for different years using the same fleet characteristics we used for ARC's conformity determination for the Envision6 RTP last year. The outputs of Mobile6 are emission factors by year and vehicle type in grams/mile. The only variable in Mobile that you can change to impact CO2 emissions factors is fuel economy. So we adjusted future fuel economy for the light duty fleet starting in 2011 according to the regulations set forth in the Energy Independence and Security Act from December 2007.

For 1990 we assumed year 2005 CO2 emission factors would be the same, so we used GDOT recorded VMT's for the region and multiplied them by the ef's.

The other variable that impacts total CO2 is vmt. After running Mobile, we multiply the ef's by the VMT from the regional travel demand model. We have a variety of regional

transportation and land use scenarios we test for the year 2030, and used these to determine future ranges of VMT and CO2 emissions.

Please ask questions if anything is unclear.

David

B.2 Beatriz Del Valle, Lead Coordinator for the Mexico City Climate Change Program

B.2.1 First Original Email

From: Nicholas Schmidt
To: Beatriz Del Valle
Sent: Thursday, November 08, 2007 9:10 AM
Subject: Climate Change Strategies for Mexico City

Good morning,

First and foremost I apologize that this email is in English, but it is the only language I speak, which makes international emails like this difficult. Thank you for taking the time to read this email.

My name is Nick Schmidt and I am a graduate student at Georgia Tech in Atlanta, Georgia. I am writing my thesis paper on climate change and transportation planning. Specifically, I am looking into how United States cities compare to international cities with respect to addressing climate change in transportation planning. I came across your email address and Mexico City's climate change plan while searching on the internet. I was wondering if there are any documents or resources available (preferably any in English) that help explain what Mexico City is doing for climate change with respect to transportation planning. Or if you could point me in the right direction so that I may find something useful, I would be very grateful.

Thank you so much for time. Any help would be greatly appreciated. Again I apologize for the email in English. Have a great day!

-Nick Schmidt

B.2.2 First Response E-mail

Date: Fri, 16 Nov 2007 13:15:48
From: Beatriz Del Valle
To: Nicholas Schmidt

Subject: Re: Climate Change Strategies for Mexico City

Nicholas:

My english is so bad, but I try to explain about the plans for transportation in Mexico City in order to GHG emissions mitigation,

In this year, Climate Change and CDM Projects Direction in Mexico City Governmet is working in a Mexico City Climate Change Plan, we have identify 6 themes: Water, Energy, Transport, Solid Wasted, Education and Climate Change Adaptation,

This Plan consider identify the GHG mitigation and adaptation measures that can be development between the next five years (2008-2012), for example in transport sector we have planned to built two lines of clean bus rapid transit (BRT) or transport corridors each year, in order that in the next five years we have installed ten lines of this transport, I attach a file with this information,

In this moment we are identify other actions and we will expect in january 2008 we will shows the Mexico Ciy Climate Change Plan,

Other actions are development in Transport Secretary, I try to look for,

The contact in Metrobus is Wendy Garcia

I hope this information are useful for you,

If you need additional information, don't hesitate to contact me,

Beatriz

B.2.3 Second Original E-mail

From: Nicholas Schmidt

To: Beatriz Del Valle

Sent: Thursday, January 17, 2008 2:54 PM

Subject: Re: Climate Change Strategies for Mexico City

Beatriz,

Thank you so much for the information! I read that the Climate Change Plan will be coming out this month, correct? If you have time could you email me when it becomes available, please? I would appreciate it so much.

Thanks again,
Nicholas Schmidt

B.2.4 Second Response E-mail

Date: Mon, 21 Jan 2008 11:24:46
From: Beatriz Del Valle
To: Nicholas Schmidt
Subject: Re: Climate Change Strategies for Mexico City

Nicholas:

Actually we continue working with the México City Climate Change Plan,

We have been some difficulties in order to finish this,

But we will expect finish in the next month

Beatriz

B.3 Leif Hockstad, United States Environmental Protection Agency

B.3.1 Original E-mail

To: Leif Hockstad, Lisa Hanle/
From: Nicholas Schmidt
Date: 03/05/2008 09:50PM
Subject: Missing Data from "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2005"

Dear Mr. Leif Hockstad and/or Ms. Lisa Hanle,

First of all I just want to say that the recent report, "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2005," is great. However, I am trying to find a certain piece of data that I just cannot see anywhere.

I am a graduate student at Georgia Tech and my thesis topic is trying to figure out how climate change can be worked into the transportation planning process. I am using the recent EPA emissions report for some background statistics and data trends. Specifically, I am trying to find the emissions allocated to the economic sector of transportation. Table ES-7 provides me with half the data from 1990 to 2005, but I cannot find the years 1991-1994 and 1996-1999. As you can see from Table ES-7, I only have years 1990, 1995, and 2000-2005. I couldn't find the missing years anywhere in the document, the appendix, or the website.

Do you happen to have this data, or can you direct me to someone that does have the data? I would greatly appreciate it.

Thank you and have a wonderful day.

-Nick Schmidt

B.3.2 Response E-mail

In the interest of space for formatting the printed U.S. GHG Inventory report, we only detail a limited number of years in the tables. However, all data for all years in the 1990 to 2005 time series are available in electronic format. I have attached the complete Table ES-7.

If you are interested in the full time series for other tables in the report, I can send you a copy of the CD that is enclosed with the printed U.S. GHG Inventory report. That CD has all the tables in CSV format, which is easily imported in to Microsoft Excel.

If you would like a CD, please send me a mailing address and I can mail it to you.

I hope this helps.

Thanks,
Leif

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